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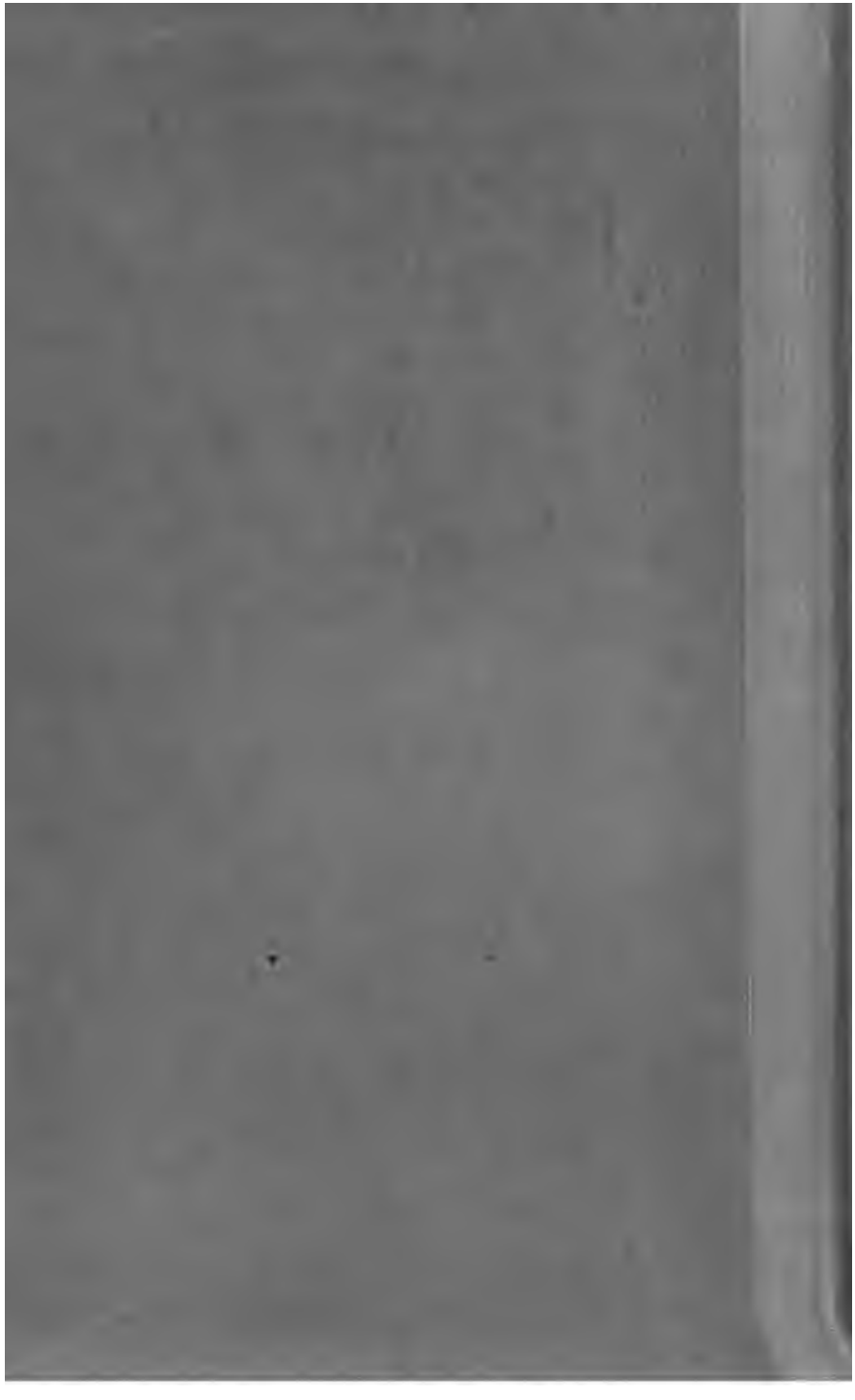
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Scientific American Series

HOME MECHANICS

FOR AMATEURS



BY

GEORGE M. HOPKINS

AUTHOR OF "*Experimental Science*"

MUNN & CO., PUBLISHERS

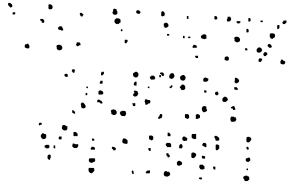
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PREFACE

SPECIAL INTEREST always attaches to a posthumous work. It is not always, however, that a work of this character possesses equal merit with one entirely completed before the death of the author. As a rule such works have not had the advantage of the final perusal and correction by the author. Such has not, however, been the case in the present instance, for the following work by the late George M. Hopkins, was completed before his death. There is no doubt, however, that this volume will come as a surprise to thousands who have closely followed Mr. Hopkins' work, and who have enjoyed making the many experiments described by him. The present volume contains much matter which has never before appeared in print, and some articles which have already been published in the Scientific American. The object of the work is to furnish food for thought to the amateur, and to give him suggestions whereby he may pass many pleasant hours in his work-shop. Mr. Hopkins was an expert mechanic. One of his chief pleasures was to make experiments at his home in his well-equipped work-shop and laboratory, and the work described in the present volume is nearly all the result of experiments made by him during such "idle" hours. It has been the intent of the author to make the present

work as suggestive as possible. No complicated apparatus is required in carrying out the experiments described. Any one with ordinary mechanical ingenuity and having a lathe and a few tools can make most of the experiments described in these pages.

A few articles by other authors have been included as they are germane to the scope of the book. It is hoped that "Home Mechanics for Amateurs" will prove helpful to as many thousands as has "Experimental Science."

TABLE OF CONTENTS

PART I.

WOOD-WORKING

An Inexpensive Turning Lathe. Turning. Wood-Working on a Lathe. Work Bench and Tools for Woodwork. Whittling. Different Shapes of Saw Teeth and the Way they Cut. A Wrinkle in Sawing. Wood Carving 1

PART II.

HOW TO MAKE HOUSEHOLD ORNAMENTS

Home-made Grilles and Gratings. Wall Ornaments. Pseudo-Ceramics. Imitation of Majolica. Stained Glass and Objects of Wire Cloth. Japanese Portiere or Curtain. Repousse. An Easy Method of Producing Bas-reliefs. Ornamental Iron Work for Amateurs. Some Things in Wire. Some Things in Burnished Brass. Forming Plaster Objects 31

PART III.

METAL-WORKING

Sawing Metals. Soldering. Grinding and Polishing. Silver Work. Metal Foot Lathe. Drills and Drilling. Centering and Steadying. Chucking. Metal Turning. Chasing and Knurling. Rotary Cutters. Easily made Slide Rest. Index Plates for Gear Cutting. Gear Cutting Apparatus. Hints on Model Making. Metal Spinning 89

TABLE OF CONTENTS

PART IV.

Model Engines and Boilers

A Home-made Steam Engine. A Safe Way of Running a Small Engine. A Miniature Caloric Engine. An Inexpensive Water Motor 169

PART V.

Meteorology

Self-Recording Instruments. What may be learned by the Use of the Meteorological Instruments. A Weather Vane. Wind Pressure Gauge. Rain Gauge. A Metallic Thermometer. A Simple Hygroscope. A Mercurial Barometer. 187

PART VI.

Telescopes and Microscopes

How to make a Telescope. The Microscope 207

PART VII.

Electricity

A Practical Primary Battery. Electric Lighting for Amateurs. The Electric Chime. Home-made Electric Night Lamp. An Electrical Cabinet. Simple Electric Motor. Small Electric Motor for Amateurs. How to make a Sewing Machine Motor without Castings. A Design for an Electric Launch Motor. How to make an Edison Dynamo and Motor. The Utilization of 110 Volt Electric Circuits for Small Furnace Work. Recording Telegraph for Amateurs. How to make a Telephone 227

PART I.

WOOD-WORKING

AN INEXPENSIVE TURNING LATHE

THE BOY who has a turning lathe can readily make many things which he might not feel disposed to buy; for example, he can make tops, ninepins, and ornamental and useful objects without much trouble and with very little expense. The ancient lathe consisted of two conical points, supported in position by suitable standards, and the work to be done was whirled on these points by means of a strong cord wrapped once around the stick to be turned, with the upper end attached to a spring pole and the lower end secured to a treadle. The lathe we are about to describe is one remove from this primitive lathe of the olden time. It has the two standards with points or dead centers, as they would be called by machinists, but one of the points projects far enough from the standard to receive a hard wood pulley, having inserted in its side, at diametrically opposite points, two spurs, which enter the end of the piece of wood to be turned, so that when the pulley is revolved by a belt, the wood will be turned on the centers.

This lathe is made almost entirely from strips of hard wood, 1 inch thick and $2\frac{1}{2}$ inches wide. These strips can be easily furnished by any carpenter, cabinet maker or wagon maker, and an old table may be used for the frame.

The bed-piece is made of two such strips, 2 feet long, and a block of the same material, 1 inch square and 2

inches long, at one end is placed between the strips and held in place by wood screws. A piece of thick paper is placed between the block and one of the strips,



FIG. 1. An Easily Constructed Wood Lathe.

to make the space between the strips a little wider than the thickness of the block.

To each end of the bed is secured a foot, consisting of a piece of the same strip, 6 inches long. These are secured by wood screws passing upward through holes

in the lower edge of the foot, the holes being deeply countersunk to let in the heads of the screws.

The head stock and tail stock are nearly alike, in so far as the wood work is concerned. Each is formed of three pieces of the strip from which the bed is made. To opposite sides of a central piece, 7½ inches long, are secured side pieces 4 inches long, by means of screws. These side pieces must of course be square on the end so that they will set squarely on the bed when the projecting end of the central piece is inserted

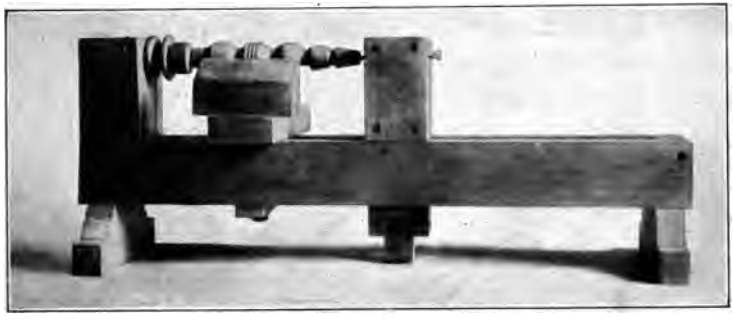


FIG. 2. Work in the Lathe.

in the slot of the bed. The lower end of the center piece is mortised to receive a wooden key or wedge, which clamps the tail stock to the bed. In the tail stock, ½ inch from the top, is bored a hole in which is inserted a large wood screw, the point of which is filed conically, as shown. In the head stock is also bored a hole corresponding with that of the tail stock, to receive a large wood screw, ¼ or 5-16 inch in diameter. The head of this screw is cut off, and the head end is filed off conically. This point should project about an inch from the head stock, and to the plain, smooth pro-

jecting part of the screw is fitted a small grooved pulley about 1½ inches in diameter at the bottom of the groove. The pulley should be of Babbitt metal or type metal. In the side of the pulley, about ¼ inch from the hole, are inserted two small screws, about ⅝ inch long, which are allowed to project; these screws are filed to form chisel-edged spurs for driving the work in the lathe. The points should project as far as the point of the conical end of the large screw.

The lower end of the head stock—which is about 2¼ inches long—is inserted between the strips forming the bed, and fastened with screws; a piece of paper being inserted to increase the space between the strips, so that the tail stock can be moved easily.

The wood to be turned has a small hole—say, ⅛ inch—bored in the center at each end, and is placed between the centers; the tail stock having been clamped in the proper position, the tail screw is turned with a screw driver until it is forced a short distance into the end of the stick. Then the stick is driven forward on to the center, and spurs of the head stock, and the screw in the tail stock is turned so as to hold the stick, but not enough to create friction. A drop of oil should be put on each center, and the pulley should be oiled.

The rest on which the gouge or chisel is placed while the turning is being done consists of a piece of the wooden strip with a slot in it to allow a 5-inch carriage bolt to pass through. This bolt extends through the slot of the bed, and through a block or washer below. A wing nut is placed on the bolt so that the rest may be clamped in any desired position. To the end of the slotted piece is secured a short piece of the wooden

strip by two screws passing through the slotted piece and into the wood. The wooden rest should be beveled as shown.

It must be frankly admitted this lathe is not an elegant machine to look at, but it is capable of turning out quite reputable small work.

Having made the lathe, it will be necessary to provide some means to drive it. In almost every city and town may be found old sewing machine tables, which have been taken in trade as old iron. One of these can be bought cheaply, and when the treadle is turned around and a round leather belt applied to the lathe pulley and the sewing machine wheel, the arrangement is complete.

Some one may be found good enough to loan a sewing table for the purpose. In this case, an assistant will be obliged to work the treadle while the turning is being done.

As the flywheel should be heavy, not less than 20 pounds, and as it should be about 20 inches in diameter to secure the desired speed, it is perhaps better to fit up the lathe with a wheel and table better adapted to it than a sewing machine wheel and table would be.

The lathe shown in the illustration is mounted on a common kitchen table of the smallest size. In this case, an old wheel is selected at the junk shop; one with a groove in the edge is to be preferred, but a flat rim will answer. The one here shown has a flat face and is provided with a shaft, a crank and standards. The standards are inverted and fastened with screws to the under side of the table top.

A strip of board extending lengthwise of the table is attached to the rear legs with screws, and the piece

of board forming the treadle is hinged to it in position to receive the screw which passes through the lower end of the pitman rod or connecting rod, the upper end being apertured to receive the crank pin. A round leather belt is used in this case.

The tools for turning are not very expensive; with two gouges and one or two flat chisels a great variety of work may be done.

TURNING

There is no secret in turning. It requires a great deal of practice to become an expert, but beyond acquiring the first principles nothing further than practice is required. When reducing a piece of wood to the

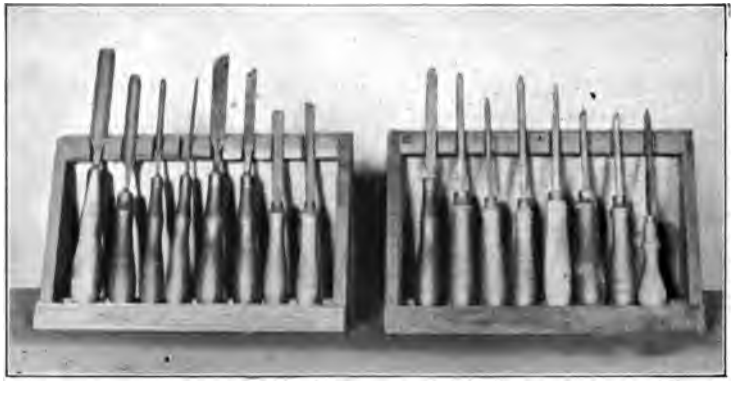


FIG. 3. Lathe Turning Tools.

desired approximate size, the gouge is held on the rest with its handle-end inclined downward at an angle of about 60° with the horizontal, the rest being near the work, and the gouge is moved back and forth on the

rest, taking off a slight shaving each time it is moved. The handle is held in the right hand, while the blade of the gouge is held in the left hand, with the thumb pressing on the concave side. If a plain cylinder is required it may be made by using the flat chisel, laying the beveled edge on the work in such a manner as to produce a drawing cut as the wood passes the edge. If the work is to be cut into at right angles or at any other angle, the chisel is placed on its edge on the rest and held firmly while moving it forward.

In cutting concave forms the gouge is made to make a drawing cut by placing it partly on its edge on the rest. It will be found necessary in either of these cases to hold the tool very firmly on the rest to prevent the edge from drawing itself forward on the wood and spoiling the work. By practice the art of wood-turning can be readily acquired even by the use of the "Simple Lathe."

For hard wood and ivory a different class of tools is required. The chisels are all flat, not oblique; some of them have edges that are square across; some have V-shaped points and others are round-nosed. For under-cuts and odd work, special tools are bent at different angles. Flat work, such as rosettes, etc., is chucked upon the face plate, or attached with screws to a board fixed to the face plate.

In finishing work the use of fine sandpaper is admissible, but it never should be used to correct poor turning. Wood work, when smoothed a little with fine sandpaper, may be finished by applying to it with a cloth a mixture of shellac varnish and linseed oil, in proportion of about one part of oil to two of shellac. Only a little is applied to the cloth at one time, the pol-

ish being well shaken before it is applied. The work in the lathe is rapidly revolved until it is brightly polished and the shellac varnish is hard. If desired, the work may be stained before it is polished. The stains are readily obtainable, and are described in the "Scientific American Cyclopedia of Receipts, Notes and Queries."

WOOD-WORKING ON A LATHE

It is not the intention of the writer to enter largely into the subject of wood-working, but simply to suggest a few handy attachments to the foot lathe which will greatly facilitate the operations of the amateur

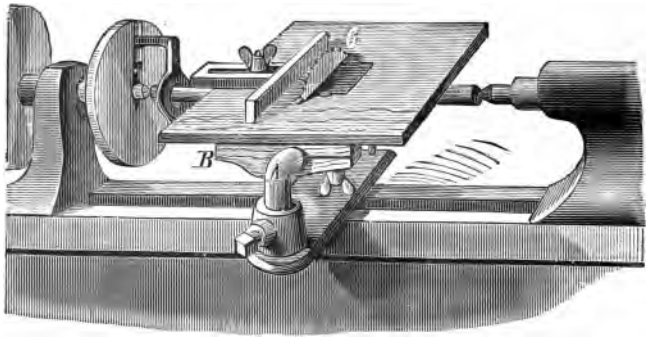


FIG. 4. Saw Table.

wood worker, and will be found very useful by almost any one working in wood. It is not an easy matter to split even thin lumber into strips of uniform width by means of a handsaw, but by using the circular saw attachment, shown in Fig. 4, the operation becomes rapid and easy, and the stuff may be sawed or slit at any desired angle or bevel. The attachment consists of a saw mandrel of the usual form, and a wooden table supported by a right angled piece, A, of round iron

fitted to the toolpost and clamped by a wooden cleat, B, which is secured to the under side of the table, split from the aperture to one end, and provided with a thumbscrew for drawing the parts together. By means of this arrangement the table may be inclined to a limited angle in either direction, the slot through which the saw projects being enlarged below to admit of this adjustment.

The back of the table is steadied by a screw which rests upon the back end of the tool rest support, and enters a block attached to the under side of the table. The gauge at the top of the table is used in slitting and for other purposes which will be presently mentioned, and it is adjusted by aid of lines made across the table parallel with the saw.

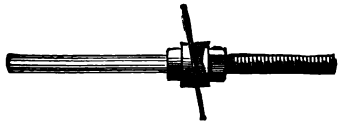


FIG. 5.
Saw between beveled Washers.

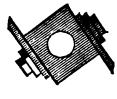


FIG. 6.
Moulding Knives.

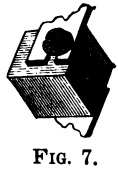


FIG. 7.

For the purpose of cross-cutting or cutting on a bevel a thin sliding table is fitted to slide upon the main table, and is provided with a gauge which is capable of being adjusted at any desired angle. For cutting slots for panels, etc., thick saws may be used, or the saw may be made to wabble by placing it between two beveled washers, as shown in Fig. 5.

The saw table has an inserted portion, C, held in place by two screws which may be removed when it is desired to use the saw mandrel for carrying a sticker head for planing small strips of moulding or reeding.

(Figs. 6 and 7.) The head for holding the moulding knives is best made of good tough brass or steam metal. The knives can be made of good saw steel about $\frac{1}{8}$ inch thick. They may be filed into shape and afterward tempered. They are slotted and held to their places on the head by means of $\frac{1}{4}$-inch machine screws. It is not absolutely necessary to use two knives, but when only one is employed a counterbalance should be fastened to the head in place of the other. All kinds of moulding, beading, tonguing and grooving may be done with this attachment, the gauge being used to guide the

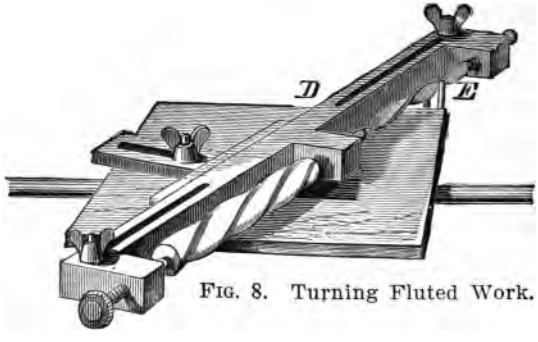


FIG. 8. Turning Fluted Work.

edge of the stuff. If the boards are too thin to support themselves against the action of the knives they must be backed up by a thick strip of wood planed true. The speed for this cutter head should be as great as possible.

Fig. 8 shows an attachment to be used in connection with the cutter head and saw table for cutting straight, spiral or irregular flutes on turned work. It consists of a bar, D, carrying a central fixed arm, and at either end an adjustable arm, the purpose of the latter being to adapt the device to work of different lengths. The arm projecting from the center of the bar, D, sup-

ports an arbor having at one end a socket for receiving the twisted iron bar, E, and at the other end a center and a short finger or pin. A metal disk having three spurs, a central aperture and a series of holes equally distant from the center and from each other, is attached by its spurs to the end of the cylinder to be fluted, and the center of the arbor in the arm, D, enters the central hole in the disk while its finger enters

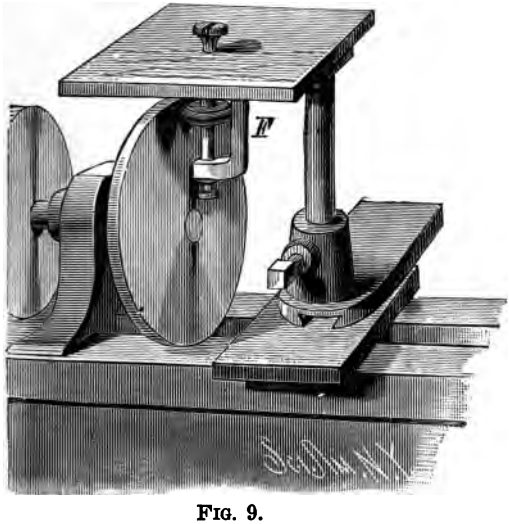


FIG. 9.

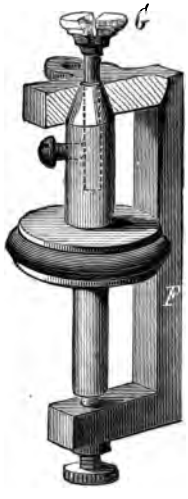


FIG. 10.

Moulding Irregular Work.

one of the other holes. The opposite end of the cylinder is supported by a center screw. A fork attached to the back of the table embraces the twisted iron, E, so that as the wooden cylinder is moved diagonally over the cutter it is slowly rotated, making a spiral cut. After the first cut is made the finger of the arbor is removed from the disk and placed in an adjoining hole, when the second cut is made, and so on.

Figs. 9 and 10 show a convenient and easily made attachment for moulding the edges of irregular work, such as brackets, frames, parts of patterns, etc. It consists of a brass frame, F, supporting a small mandrel turning at the top in a conical bearing in the frame, and at the bottom upon a conical screw. A very small grooved pulley is fastened to the mandrel and surrounded by a rubber ring which bears against the face plate of the lathe, as shown in the engraving. The frame, F, is let into a wooden table supported by an

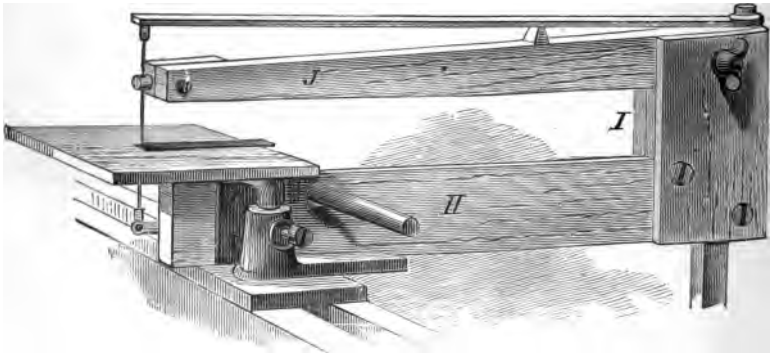


FIG. 11. Scroll Saw.

iron rod which is received by the tool rest holder of the lathe. The cutter, G, is made by turning upon a piece of steel the reverse of the required moulding, and slotting it transversely to form cutting edges. The shank of the cutter is fitted to a hole in the mandrel and secured in place by a small set screw. The edge of the work is permitted to bear against the shank of the cutter. Should the face plate of the lathe be too small to give the required speed, a wooden disk may be attached to it by means of screws and turned off.

Figs. 11, 12, and 13 represent a cheaply and easily made scroll saw attachment for the foot lathe. It is made entirely of wood and is practically noiseless. The board, H, supports two uprights, I, between which is pivoted the arm, J, whose under side is parallel with the edge of the board. A block is placed between the uprights, I, to limit the downward movement of the arm, and the arm is clamped by a bolt which passes through it and through the two uprights and is provided with a wing nut.

A wooden table, secured to the upper edge of the board, H, is perforated to allow the saw to pass

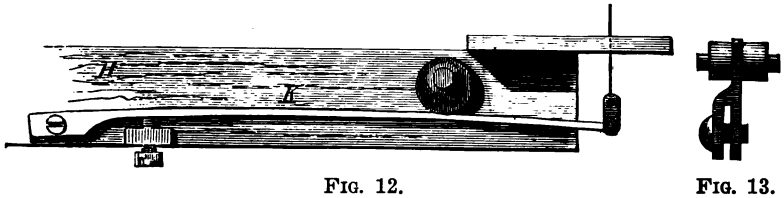


FIG. 12.
Details of Saw.

FIG. 13.

through, and is provided with an inserted hardwood strip which supports the back of the saw, and which may be moved forward from time to time and cut off as it becomes worn. The upper guide of the saw consists of a round piece of hard wood inserted in a hole bored in the end of the arm, J. The upper end of the saw is secured in a small steel clamp pivoted in a slot in the end of a wooden spring secured to the top of the arm, J, and the lower end of the saw is secured in a similar clamp pivoted to the end of the wooden spring, K. Fig. 13 is an enlarged view showing the construction of clamp.

The relation of the spring, K, to the board, H, and to

the other part is shown in Fig. 12. It is attached to the side of the board and is pressed upward by an adjusting screw near its fixed end.

The saw is driven by a wooden eccentric placed on the saw mandrel shown in Figs. 4 and 5, and the spring, K, always pressed upward against the eccentric by its own elasticity, and it is also drawn in an upward direction by the upper spring. This arrangement insures a continuous contact between the spring, K, and the eccentric, and consequently avoids noise. The friction surfaces of the eccentric and spring may be lubricated with tallow and plumbago. The eccentric may, with advantage, be made of metal.

The tension of the upper spring may be varied by putting under it blocks of different heights, or the screw which holds the back end may be used for this purpose.

The saw is attached to the lathe by means of an iron bent twice at right angles, attached to the board, H, and fitted to the tool rest support. The rear end of the sawing apparatus may be supported by a brace running to the lower part of the lathe or to the floor.

The simple attachments above described will enable the possessor to make many small articles of furniture which he would not undertake without them, and for making models of small patterns they are almost invaluable.

WORK BENCH AND TOOLS FOR WOODWORK

The first thing required by the amateur workman is a bench with a few tools for wood working. The bench need not necessarily be a long and heavy structure like

a carpenter's bench, as the work to be done by the amateur is mostly small, requiring but little material and small room. A table like that shown in connection with the simple lathe will answer, or the rear portion of the lathe table may be used as a bench. A small wooden vise is secured to the side of the table near the left hand end, and in the top of the table is inserted a common flat headed wood screw, which may be screwed down even with the top of the table, or raised $\frac{1}{8}$ or $\frac{1}{4}$ inch, as the work may require. This screw takes the place of the usual bench dog, and holds the end of a piece of wood while it is being planed. Two planes are required to begin with, a jack plane and a smooth plane. A good fine cross-cut saw will probably answer for all ordinary sawing, and it may be used as a rip saw when only a little of this kind of work is required. Two chisels, one $\frac{3}{4}$ inch, the other $\frac{1}{4}$ inch, and two gouges of about the same width, will be needed. A hammer and a screwdriver, together with a brad awl and a foot rule complete an outfit that will enable the owner to do a great deal of work.

Of course a good oil stone should be at hand for sharpening the tools, and they should be kept sharp.

Chisels and plane irons must be held at an angle of about 60° to the surface of the stone and moved back and forth on the stone until an edge is produced. The straight side of the tool must be kept from the oil stone.

While the tool is being sharpened the oil stone must be lubricated with a few drops of sewing machine oil or bicycle oil. When the tools need grinding it is advisable to have the work done by a competent workman.

The plane irons are set so that the edge is seen all the way across the wood of the plane and secured by driv-

ing in the wedge. If the tool projects so as to make a thick shaving, the wedge is loosened slightly and the iron is made to rise slightly by tapping with a hammer on the top of the plane. The iron may be adjusted laterally by tapping the iron on one edge or the other near the top, and it may be forced downward by a few light taps on the upper end.

After some observation—every boy has opportunities for observation—and after practice, the amateur will be able to do an ordinary job of carpentry, and he will seek after a few more tools, such for example as a try-square, a bit-stock and a few bits, a few clamps and a glue pot. He can then enter into the work heartily, and not only make needed repairs, but construct many plain little articles such as boxes with hinged covers, cabinets, screen frames, etc. The main requirements are to construct each part as carefully as possible, to assemble the parts with equal care, and to never use plugs or putty, or in other ways patch up for bad workmanship. If a mistake is made, it is generally better to throw the part away and begin again rather than to patch.

WHITTLING

The boy who is a good whittler will make a good mechanic, or will at least understand mechanics well enough to know a good job from a poor one, and will be able to help himself in many an emergency. Real proficiency with a jack-knife implies a knowledge of mechanics and exhibits an aptitude for mechanical work which only needs opportunity and encouragement to reach a useful stage of development.

A jack-knife is a very simple tool, but without doubt

it is more generally useful than any other. For whittling, an ordinary two or four-bladed knife should be selected. It should have a good-sized handle and its blades should be fine and well tempered. With the knife should be purchased a fine, sharp oil stone, and the knife should be kept sharp, as it is impossible even



FIG. 14. Knives adapted for Whittling.

for an expert workman to do good work with a dull knife.

In sharpening the knife, the blade should be kept at an angle of about 20° with the face of the stone and rubbed back and forth the full length of the stone about an equal number of times for opposite sides of the blade, until it appears to be sharp, the stone meantime being lubricated with water or oil; then it may be stropped like a razor on a strip of leather until it is literally as sharp as a razor.

In whittling curious and ornamental objects, seasoned straight-grained white pine should be selected

The piece should be a little larger than the finished work, and the design should be laid out in pencil on one side of the block, when it can be sawed out with a scroll saw. If the form can be traced on the edge of the work much whittling may be avoided by doing more sawing. The knife work may now proceed. It is well to begin with the heavier portions and finish with the lighter portions.

As much should be done as possible without the use of sand paper. If it can all be done without sand paper so much the better. It will sometimes be found necessary to put on the finishing touches with a piece of very fine sand paper. Blades of different forms are found useful, and in some kinds of work a penknife blade which has been broken off rather short will prove exceedingly useful when the blade has been repointed.

The saw used for shaping the work may be like the one on pages 12 and 13, or one of the small scroll sawing machines so much in use at one time would be still better.

A very pretty example of whittling is the chain whose links are formed from a single bar of wood of O-shaped cross section. To make a good job the bar should be evenly spaced, and the links drawn on the sides of the bar. Then holes are bored diagonally through the bar. At the angle the cutting proceeds slowly and cautiously, finishing the link as far as possible before it is cut loose. If any sandpapering is to be done it should be done as far as possible before the link is cut loose. In the example shown, only a portion of the wooden bar has been formed with links, the remainder being left to give an idea of the method.

It is more difficult to whittle a pair of pliers from a

single piece of wood, so that the jaws work freely, and at the same time the joints are neat.



FIG. 15. Examples of Whittled Work.

The blank for the pliers is sawed from $\frac{1}{2}$-inch pine. The sides of the pliers where the joint is to be formed are finished and the joint is carefully laid out in fine

lines. Then with a very thin knife blade inserted from each side the central portion of the joint is cut through; thin incisions are made in the sides to intersect the other cuts. The jaws of the pliers are carefully separated by cutting from either side, and the cuts which separate the inside piece are then made with great care. The outside of the jaws and the handles are now finished. In cutting the joint the wood is somewhat compressed by the insertion of the knife, and the joint appears badly made. By soaking the wood in water for a half-hour or so the wood resumes its normal condition, and the joint becomes tight. When the wood is dry the finishing may be done with a knife and with fine sand paper.

The tower containing the balls and the revolving spindle is cut from a single bar of wood, with the balls and spheroid formed with a knife in the places they now occupy. The design is carefully drawn on the bar, and the work begins by making a diagonal cut across each corner for the corner posts, not cutting through the floors of the different stories. Then the inner postern is cut roughly in the form of a cylinder. The cross cuts are then made and the pieces are shaped into balls. The spindle in the lower story is formed in the same way, but it is cut loose by running the point of the knife into the apexes of the cones formed above and below the spheroid, thus at one operation forming the points of the spindle and the bearings for them. The posts at the corners are left as large as possible and finished finally by taking off only enough wood to make them straight and square.

An anchor with its cross bar and ring is made of a single piece of wood a little thicker than the width of

the flukes. The cross bar is whittled out parallel with the shank of the anchor, and the curved end is cut across the grain. The hole in the shank is formed at the same time the curved end is cut loose. The shoulder on the bar is thus formed and the bar is pushed through the hole in the shank. A small mortise is made in the bar to receive the key which keeps it in place. The ring at the top of the anchor is made in the same manner as the first link of the chain. The anchor looks very simple, but it is in reality quite difficult.

In all these examples the wood should not be cut away more than is necessary, except to finish.

The puzzle shown assembled and separated cannot readily be described. The pieces are notched so that they will go together and form the symmetrical whole, as shown in the engraving.

DIFFERENT SHAPES OF SAW TEETH AND THE WAY THEY CUT*

The accompanying sketches show the different shapes of saw teeth and the way that they cut the timber. Fig. 16 shows the dress of a shingle saw tooth. By examin-



FIG. 16. The "Dress" of a Shingle Saw Tooth.

ing it, it will be seen that it is a "sprung tooth," and the teeth cut on alternate sides of kerf, taking two teeth to clear out the kerf on both sides. The bevel of the teeth gives it a shear cut on the timber. The wood will slip on the edge of the teeth, wearing them on the inside and leaving the outer corner full and sharp, and a cor-

* From the Saw Mill Gazette.

ner to clear up the side of the kerf, thus making smooth lumber.

Fig. 17 shows a square dressed tooth. The wood

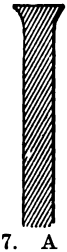


FIG. 17. A Square Dressed Tooth.

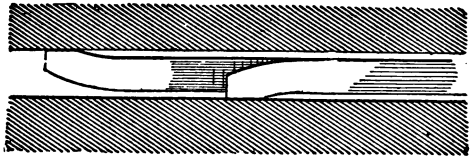


FIG. 18. A Vertical Saw with Square Teeth.

wears off the corners, leaving them dull, and they will fly from timber to the other side if the wood is not equal in hardness, and lead the saw to that side of the log. This trouble is found in wood with a hard and soft grain or in knots, but with the beveled teeth the sharp corner will lead the saw straight.

Fig. 18 shows a vertical saw with square teeth, a very common dress. The wood wears the out corner off, leaving it round or blunt, and as there is nothing to support the inside of the teeth, they will fly from the wood,

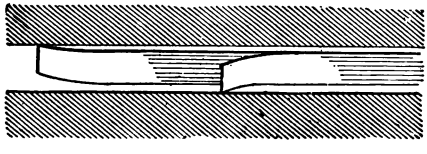


FIG. 19. A Swaged Tooth of the Same Kind as Fig. 18.

and in the up stroke of the saw wear against the side of the kerf until worn in the shape shown in cut.

Fig. 19 is a swaged tooth of the same kind of saw and is a very good dress for sash, muley, gang, and other

saws using light feed, but for heavy feed it is better to swage the teeth out on both sides and joint off for set. By referring to Fig. 20 it is seen that all teeth of this shape cut with a scrape cut, not with edge cutting, like

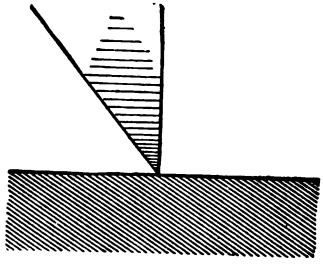


FIG. 20. Teeth that Cut with a Scrape.

a chisel, but with the edge set at right angle with the line of cut. For soft wood, such as white pine, hammer the top of the teeth, turning the edge down enough to give a cutting edge downward. Figs. 21 and 22 are circular log saws.

Fig. 21 shows a side view of a tooth. It is seen that the back of the tooth lies close to the wood, and the

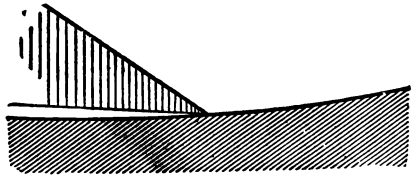


FIG. 21. Side View of Circular Saw Tooth.

tooth may be filed thin without danger of breaking. This dress of saws cut with a chisel cut, will carry more feed than any other, and at the same time do the best of work.

Fig. 22 shows the shape of the edge of the same tooth. It being hollow on the edge, with the corners sharp, the wood will fly or slip from the corners, not wearing them as much as a square tooth, leaving a good corner

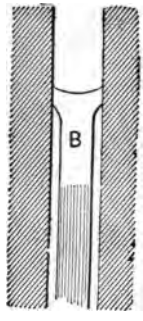


FIG. 22.
Edge of Circular Saw Tooth.

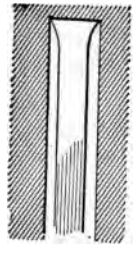


FIG. 23.
A Square Dressed Tooth.

to clear the sides of the kerf. It will be seen by referring to Fig. 22 that it takes two teeth, one on each side of the saw, to cut both sides of kerf, but in this dress each tooth cuts both sides, and again, if a beveled sprung tooth is forced to do more than a medium amount of duty, it will fly into the wood and be in danger of tearing off the teeth.

In Fig. 23 is seen a square dressed tooth. All teeth swaged with a square dress leave the corners rather weak and not much to joint off the side in setting. This shows one such tooth cutting through cross grained or twisted timber, a sharp corner but nothing to clear the side of the kerf, the cross grain filling so much of the kerf as to rub on the plate of the saw and heat it.

Fig. 24 refers to a dress for hand and other saws that



FIG. 24. Dress for Hand and other Saws.

is used for cross-cutting soft wood that is to be cut very smooth.

A WRINKLE IN SAWING

A try-square is not always at hand when it is desired to saw a stick, and when it is handy some mechanics prefer to work by "guess" than otherwise. When a bright straight saw is placed upon a stick or on the edge

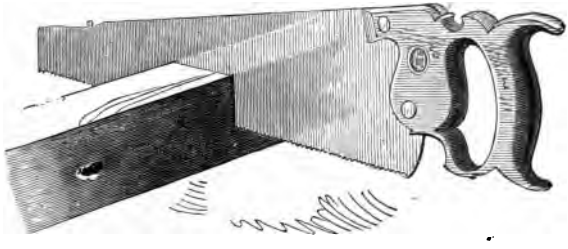


FIG. 25. Reflection Substituted for the Try Square.

of a board, the reflection of the stick or board in the saw is sufficiently well defined to permit of placing the saw so that the reflected image coincides with the object reflected, forming a continuous straight line. If the sawing is done while the image and the stick are in line, the stick will be cut at right angles.

It is obvious that a line may be drawn at right angles to the stick by arranging the saw as shown in Fig. 26. If, after forming this line, the saw be placed across the stick so that the line and its reflected image and the

stick and its reflected image form a square, with the reflected image and the stick lying in the same plane,

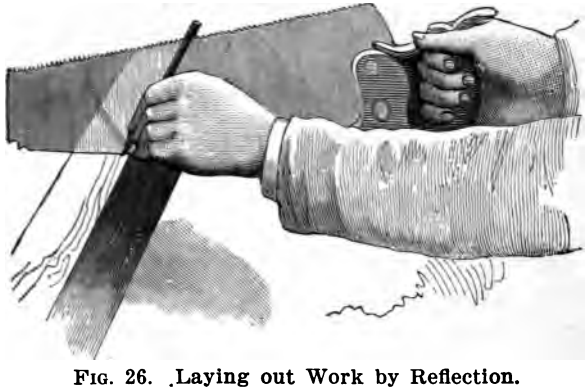


FIG. 26. Laying out Work by Reflection.

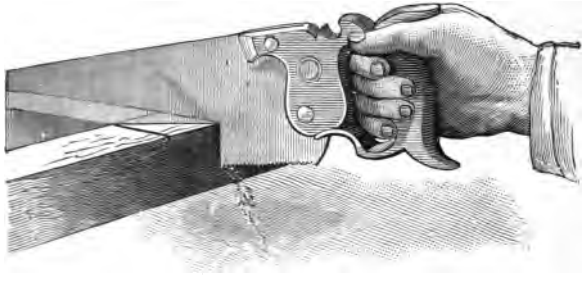


FIG. 27. Forty-five Degree Angle by Reflection.

as shown in Fig. 27, the stick may be sawed at an angle of forty-five degrees, provided the saw is held in the same position relative to the stick.

WOOD CARVING

To one having an idea of form and proportion, wood carving is not very difficult, even though a practical knowledge of drawing and modeling be wanting. Cred-

itable specimens of carving have been produced by means of the pocket knife alone, by persons having dextrous hands and good eyes; but it takes a good workman to produce a fine job with poor tools, or none at all, therefore the average wood carver will be obliged to rely somewhat upon tools and appliances. In fact, the more complete the set of tools and the more perfect the accessories, the more readily can the work be done and the more satisfactory the result.

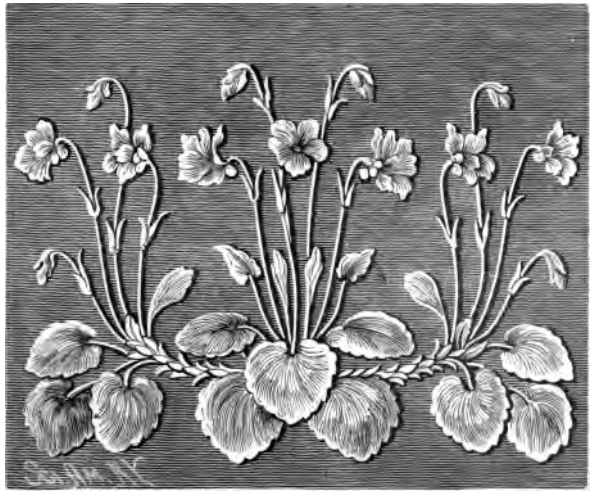


FIG. 28. Violet Panel.

The principal tools are gouges, chisels, parting tools, curved and straight, a heavy mallet, a light mallet, a solid bench, and some clamps. As to materials: For the beginner soft woods are best, such as pine, white wood, or cedar. After a little experience, pear, black walnut, and oak may be tried. Nine-tenths of the difficulty in carving is in working one's self up to the

point of setting out in the work. The chances are that in the beginning the tyro will not succeed in producing the exact forms desired; but progress will be made with every successive trial.

It is, indeed, difficult to give any explicit directions for carving. We might almost say, here are the materials, the tools, and the design. The whole of carving is to take these tools and cut this design from this piece of material, using your own judgment, at the same time "making haste slowly."

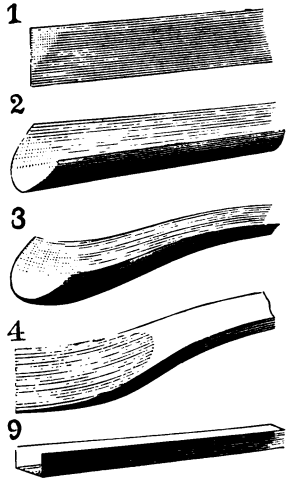


FIG. 29. Carving Tools.



FIG. 30. Edge View of Tools.

The tools required are shown in Fig. 29, 1 being a firmer, 2 a straight gouge, 3 a curved gouge, 4 a bent chisel, 5 a front-bent gouge, 6 a back-bent gouge, 7 a parting tool, 8 a curved parting tool, and 9 a macaroni tool. These tools can be purchased either separately or in sets. There are other forms and many different

sizes. It is well to begin with a half dozen medium sized tools, and then learn by experience what further tools are required. A flat and curved chisel and a flat and curved gouge, each one-half inch wide, a narrow deep gouge, and a parting tool are sufficient for the first effort.

The design is marked upon the wood to be carved, and the outline is shaped by means of a scroll saw, if the design is to be in high relief, and the most prominent is isolated from the rest. Avoid cutting too deeply, or raising slivers that run into the wood and spoil the work. Where the carving is done on a flat surface in low relief, gouges having little curvature are required.

The tools should be kept as sharp as possible, to secure smooth work and to economize labor. Carving tools are usually sharpened from both sides by means of suitable oil stone slips and by leather strops charged with crocus.

The wood while being carved is held in place on the bench by means of screw clamps, or by pointed screws passing upward through the bench into the back of the work.

In Fig. 28 is shown a panel of violets, which may be copied after some experience is gained. It is easier, however, to copy other carvings than to produce the work from engravings.

Simple subjects should be chosen, and no work should be passed until it has been made as perfect as the tools, materials, and ability of the carver will permit. A final finish imparted with fine sandpaper is admissible; but neither sandpaper nor putty should be depended upon as material aids in this kind of work.

PART II.

HOW TO MAKE HOUSEHOLD ORNAMENTS

HOME MADE GRILLES AND GRATINGS

A DWELLING HOUSE without ornamentation of the class mentioned above indicates one of three things—either the owner or occupant does not appreciate the value of this kind of home decoration or he does not possess the skill to make or the power to purchase it. It is true, the beautiful metal and wood work now manufactured for this purpose is very expensive; but it is also true that something equally as beautiful may be had without much trouble or expense.

The grilles shown in Figs. 31, 32, and 33 are made of rope, sized, bent into shape, dried, glued in a wooden frame and finally painted an appropriate color or gilded or bronzed. These ornaments when placed in a doorway or window or across a hall from the stairway to the wall, or in some corner in the library, add wonderfully to the appearance of the room.

The materials required are some $\frac{5}{16}$ inch sash cord, glue, round sticks or doweling $\frac{5}{16}$ inch in diameter, paraffine (a paraffine candle will do), some strips of wood, and paint or varnish.

There are in the present case only two fundamental forms for the spindles or bars, but these are combined in several different ways, as shown in Fig 36. The spin-

dle most used is shown in Fig. 34. It is formed by winding the sash cord—which has been previously steeped in the glue size—upon the wooden rod. The rod is coated with melted paraffine before use, to prevent the size from adhering, and equidistant marks are made upon the rod as guides for the winding. These marks are 1½ inches apart. The winding can be easily done by placing one end of the wooden rod in a vise, driving a tack through the end of the rope into the rod. If every turn of the rope around the rod is made to coincide with one of the marks, the spindle will be true enough for all purposes. A tack should be driven

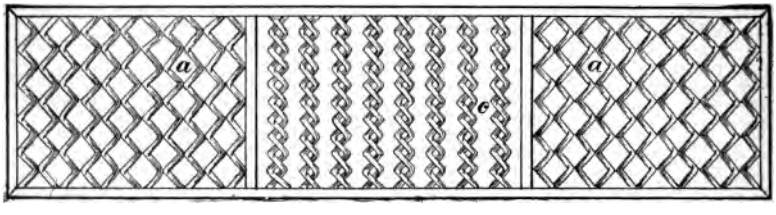


FIG. 31. Grille for Double Doors.

through the end of the finished spiral into the rod to prevent the rope from unwinding. A number of rods will be required. Part of the spindles should be wound in a right-handed direction and the remainder in a left-handed direction. The rope should be allowed to stand for a day or so to dry. It is well, especially in warm weather, to add to the size some oil of cloves or carbolic acid to prevent it from souring while drying.

The other form of spindle is shown in Fig. 35. This is made by bending the sized rope around pins driven into a board in two rows, the pins of one row alternat-

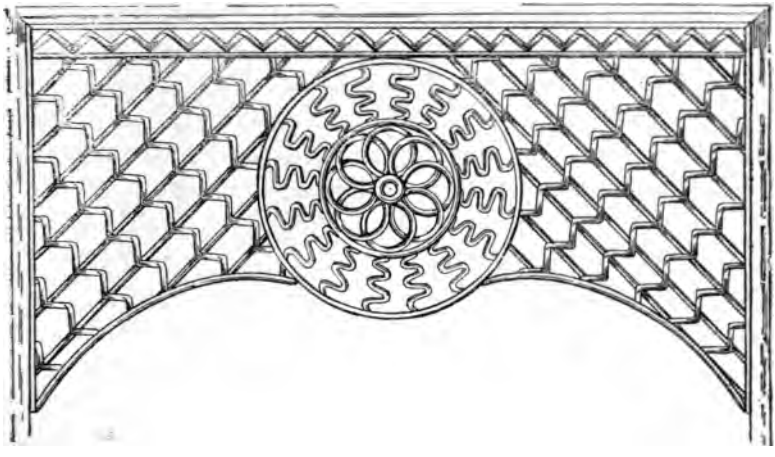


FIG. 32. Rope Grille for Window, Door, or Hall.

ing in position with those of the other row. The board and pins are covered with paraffine, as in the other case.

The spiral spindles may be combined with each other, as shown at *a, b, c, d,* and *e* in Fig. 36, and with

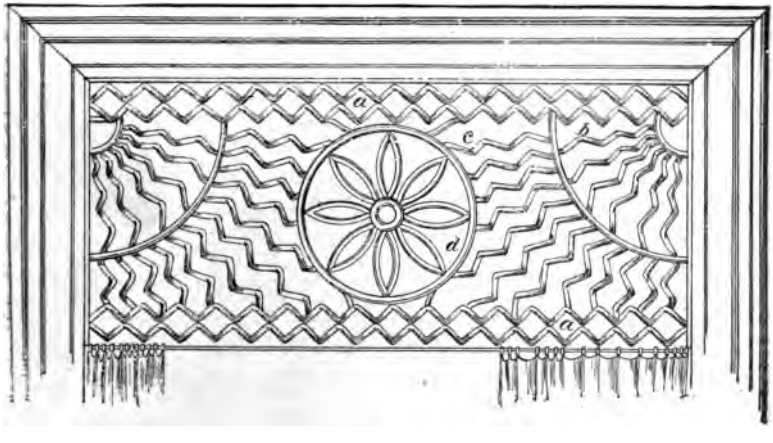


FIG. 33. Grille for Window.

a straight rod, as shown at *f*. At *g* they are shown in combination with the zigzag rope. At *h* the zigzag rope is shown in combination with straight rods.

The circles and segments of circles shown in Figs. 32 and 33 are made by winding the sized rope around a tin pail, a can, or some other cylindrical body and allowing it to dry. To form a complete ring, one turn of the rope is cut off, its ends are cut off diagonally and fastened together with strong glue.

The spindles are cut by means of a sharp knife. The various parts of the work are fastened together and attached to a light wooden frame, and, as a rule, no fastening other than glue will be required. If, however, a stronger fastening is necessary at some points, small brads or wire nails, or even screws, may be used.

In Fig. 33, the rosette, *d*, is formed of a circular ring filled with segments of a similar ring in the manner shown. Each pair of spirals, *a*, consists of one right-



FIG. 34. Spiral Spindle.

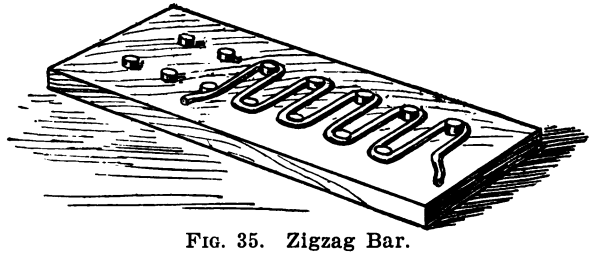


FIG. 35. Zigzag Bar.

handed one and one left-handed. The spindles, *b*, *c*, are spirals.

Grilles made in this way may be finished in the same

manner as wood. They may be stained or painted to match the work into which they are fitted, or they may be painted white and relieved by a little gilt on the projecting part.

It is obvious that a large number of patterns may be worked out by the aid of these suggestions. Different

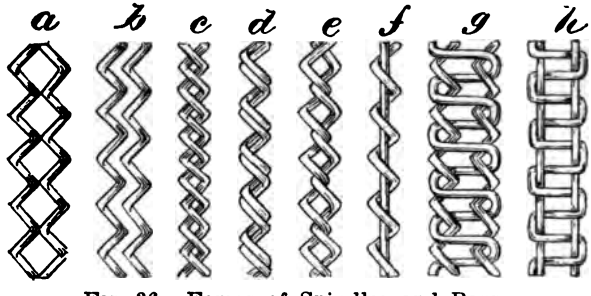


FIG. 36. Forms of Spindles and Bars.

kinds and sizes of rope may be used alone or in combination.

These grilles may be placed in windows, doorways, across halls, above mantels, across niches, between windows, and in many other places which will suggest themselves. Like many other household ornaments, if well and carefully made, they will repay the labor and trouble of making.

WALL ORNAMENTS

There is a great deal of satisfaction in the possession of home made ornamental objects, because they are the work of one's own hand, and, besides this, they are not obtained by the expenditure of money that might perhaps, be needed for other purposes.

Ornaments belonging to the wall go a long way in furnishing and beautifying the house. Pictures, care-

fully selected, are highly effective. Many of the modern photographs, photo-gravures, and photo-engravings which are really meritorious can be obtained for fifty cents or a dollar each. Some fairly good etchings and imitations of water colors are also sold at reasonable prices. The great item in connection with a low-priced picture is the frame; but any one with such tools as are commonly found about the house and with a small quantity of material can readily make a variety of frames worthy of any place in the house.

The simplest frame to make is that shown in Fig 37. This is made from a narrow flat board of chestnut,

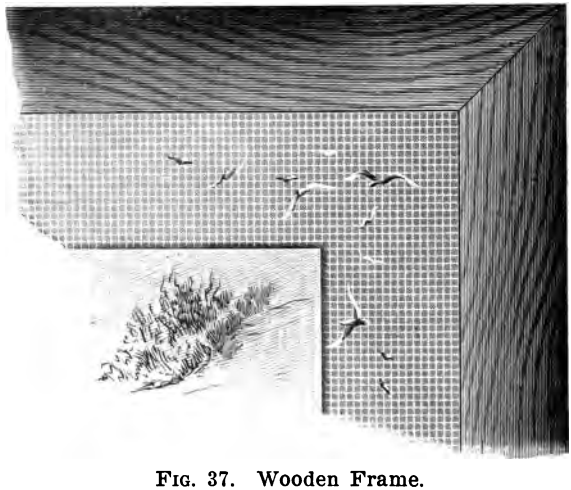


FIG. 37. Wooden Frame.

butternut, or even ash or oak, having its inner edge rabbeted to receive the glass, mat, and backing. This strip is stained and finished before it is mitered. The staining is done by brushing the strip evenly with a thin coating of asphaltum, or with a thin stain of log-

wood, or with a stain formed of either of the following dry pigments, burnt umber, burnt or raw sienna, mixed with turpentine and a very small proportion of boiled linseed oil. Chemical ink or writing fluid, reduced with water so as to produce a greenish gray tint, answers a good purpose.

After the stain is dry, the tint is lightened along the inner or outer edge of the strip, as taste may dictate, by scraping the wood by means of an ordinary wood scraper, or by rubbing the surface down by means of fine sandpaper. It is obvious that the stain may be applied to the wood in such a way as to graduate the tint without the necessity of scraping or sandpapering, but this requires practice.

The tint should be so graduated as to be very light, or nearly the natural color of the wood at one edge of the strip, while the other edge should be quite dark. The strip may be finished by flowing over it three thin coats of shellac varnish, allowing each coat to dry thoroughly before applying the next. The first two coats should be rubbed down with very fine emery paper after they become thoroughly dry and hard. The last coat may be left bright, or its luster may be toned down by means of the fine emery paper. The moulding or strip thus prepared is mitered in the usual way by the aid of a miter box, and nailed and glued together at the corners.

The mat in this case consists of a piece of thick pasteboard in which is cut an opening of the desired form. The edges of the pasteboard are beveled around the opening, and canvas, crash toweling, or white or tinted cotton velvet is secured to the pasteboard by means of bookbinder's paste (flour paste with glue added).

After the paste becomes dry, if desired, a design may be painted on the mat with water colors.

The frame shown in Fig. 38 is made on a different plan. In this case the wooden moulding is half round on its face. A saw kerf is made at the inner side of the rabbet. The edge of a strip of white or "ivory" zylonite is inserted in the saw kerf, and held there by a thin

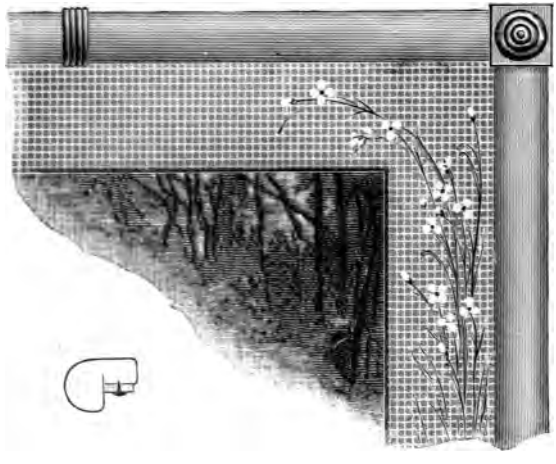


FIG. 38. Zylonite Frame.

strip of wood glued in. A small percentage of glycerine or even common molasses should be added to the glue used for this purpose. The zylonite is wrapped around the moulding and fastened by means of a thin strip of wood laid over it and secured by small nails or brads. The corners of this frame are formed by means of rectangular blocks of wood painted white on their sides and furnished on the front with a square of zylonite held in place by an ornamental brass nail.

If a larger frame is required, that can be made with

a single strip of zylonite, the joint may be covered by means of a curved half round strip of brass well polished and lacquered, and applied as shown in the engraving.

This frame may have a gilt lining as well as the mat. It has a very chaste appearance, looking much like a frame of ivory, and it is withal durable.



FIG. 39. Feather Ornament.

A very pretty and easily made wall ornament is shown in Fig. 39. It consists of a number of peacock feathers arranged radially or in the form of a fan with the quills attached to an elliptical piece of pasteboard by means of sealing wax. The pasteboard is fitted to an iridescent shell and fastened in with sealing wax. A wire loop inserted in the pasteboard serves for hanging the ornament. It may be placed between window

above or below pictures, and in many other places with good effect.

In Fig. 40 is shown a wall cabinet, which is not only highly ornamental, but very useful. The body of the cabinet is of pine or other soft wood. The doors are



Fig. 40. A Wall Cabinet.

arranged to receive the beautiful zylonite bas-reliefs sold by the manufacturers of this superb material. In openings in the back of the cabinet are inserted ornaments of the same character. They resemble ivory and are very serviceable.

The body of the cabinet is neatly covered with can-

vas, toweling, or lightly tinted cotton velvet, on which are painted designs in water or oil colors. The edges of the shelves are preferably covered with sheet zylonite, although they may with good effect be covered with the material used on the other parts of the cabinet. Ornamental brass hinges and trimmings should be applied to the doors, as shown in the engraving.

PSEUDO-CERAMICS

The ceramic art is generally practiced under conditions which render it exceedingly difficult for an ama-



FIG. 41. Square Vase.

teur to make progress in it, even so far as to produce work of the most modest and unassuming character.

In the first place it is difficult to obtain the proper quality of clay, unless one is in the vicinity of a pottery or clay bed; in the second place, even though one has the skill and practice which will enable him to shape the clay into the desired forms, still it is difficult, if not impossible to bake the work after it is done in other respects, and it can scarcely be expected that a potter will bake these odd articles. These and other difficul-



FIG. 42. Triangular Vase.

ties prevent the would-be amateur potter from attempting what, under more favorable circumstances, might be productive of works creditable to both the art and the artisan.

Recently some exceedingly plain articles of pottery, with extremely simple ornamentation, consisting merely of a little paint and a little glaze, have become very fashionable, and have been accepted as works of

art. Some of these articles are handsome, others are not. Inasmuch as these articles have no practical utility, they do not require to be made of materials either fireproof or waterproof. The requisites are simply shape, strength, and a resemblance to pottery.

The materials required for making imitation pottery are junk-board—a strong, thick board having a smooth surface—glue, and small wire nails. The ornamentation may consist of such floral or landscape decorations as the maker is able to produce if he or she be artist



FIG. 43. Cylindrical Vase.

enough to paint in oil colors. Without this ability the aid of chromos must be invoked. This will certainly afford very satisfactory results, and the expense will be slight, as very passable German chromos may be obtained for twenty-five cents each. The engravings show several examples of pseudo-ceramics which are designed with reference to the material to be employed, and compare favorably with the high-priced articles to be found in the shops.

The body of the vase shown in Fig. 41 consists of rectangular pieces of junk-board nailed and glued together at the corners, after the fashion of an ordinary wooden box. The nails used are the small wire nails used in bracket-work. They are about three-eighths of an inch long, and about the size of an ordinary pin.

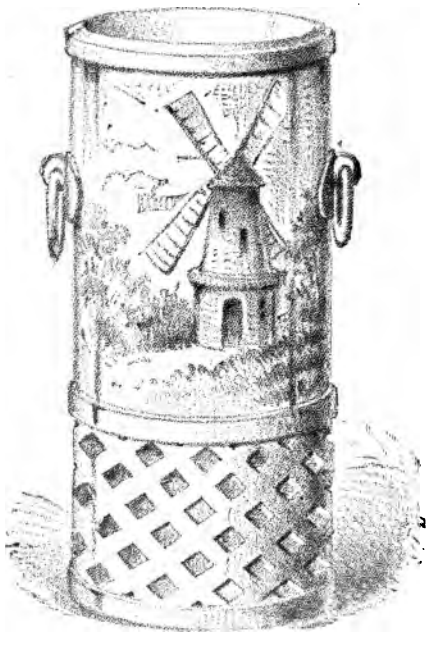


FIG. 44. Vase with Latticed Base.

In the absence of such nails common pins may be cut off and used to good advantage. Holes for these nails must be made with a fine-pointed awl. The bottom of the vase consists of a single piece of junk-board, with V-shaped notches cut from the corners to give it the bevel.

The concave sides of the top consist of sections of

paper tube such as is employed for mailing pictures. The bead around the top is of wood. Any imperfections in the joints may be filled with a mixture of glue size and whiting formed into a putty.

Fig. 42 shows a vase which can readily be made after the above hints. It is triangular in form, and has three wooden balls for legs. The band around the top is merely a narrow strip of pasteboard glued on.

Fig. 43 shows a cylindrical vase made of a strip of junk-board scarfed or beveled on the edges and lapped



FIG. 45. Elliptical Vase.

and glued. To facilitate bending the junk-board, the side which is to be outermost in the vase is wet. The bottom is glued and nailed in, and the corners are rounded with a moderately coarse file and sandpaper. A band of pasteboard finishes the top, and three or four wooden balls form the legs. The inner corner of this vase at the bottom may be filled in slightly with glue and whiting to strengthen it.

The vase shown in Fig. 44 is made in the same way as that last described. The bottom is placed above the lattice work. The latter is formed by cutting out the holes with a chisel. The ring and its fixture are made of wood.

Figs. 45, 46, and 47 are examples of "pilgrim" vases of different shapes. That shown in Fig. 47 is circular, and has convex sides or heads. The hoop is bent in the manner already described, *i. e.*, after first wetting the

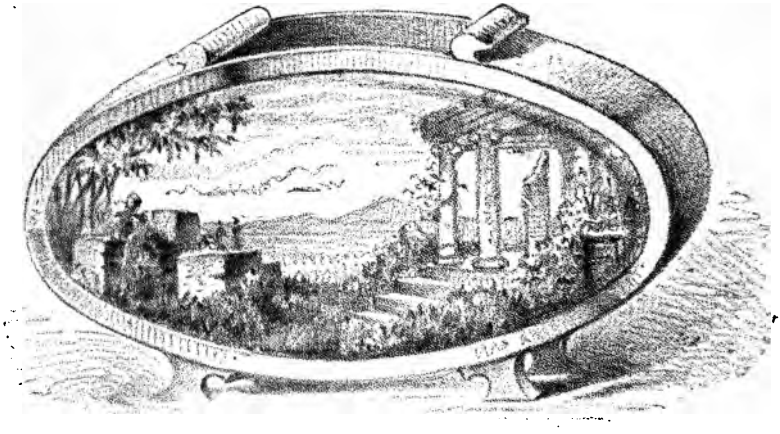


FIG. 46. "Pilgrim" Vase.

outer side. The heads are made convex by wetting the junk-board and hammering it in the middle, in the same way that a shoemaker hammers a shoe sole, or tap, to make it convex, that is, it is placed upon an ordinary flat-iron or sad-iron, and hammered with a round-faced hammer until it acquires the desired convexity. The sides are nailed and glued to the hoop, and a thin pasteboard circle is glued to each of the convex surfaces of the vase to form a border. The mouth of the vase is

made of four pieces of junk-board, glued and nailed together and secured to the vase by glue. The legs of this vase consist of two pieces of paper tube closed at the ends with turned pieces of wood. The corners of the vase may be filed and sandpapered to make it ready for further operations.

After what has already been said the construction of the vases shown in Figs. 45 and 46 will need no descrip-



FIG. 47. Circular Vase.

tion, except that the vase shown in Fig. 46 has wooden legs and wooden strips at the sides of the mouth.

The body of the vase shown in Fig. 48 can be constructed without special description. The ornamentation consists of ordinary artificial flowers and vines, secured to the body of the vase with common glue. They are stiffened by spraying or spattering shellac varnish on them from an old tooth or nail brush. They

should be sprayed several times to give them a good heavy coating of varnish. When this becomes dry the leaves and flowers may be painted in the same manner as the other parts of the vase. These vases should be smoothly finished and thoroughly dried before any attempt at finishing is made. The first operation in the way of finishing is to give the vase two coats of shellac varnish inside and out, allowing one coat to become dry before the other is applied. When both coats of varnish are dry and hard, which will require about two days, the painting may be done.

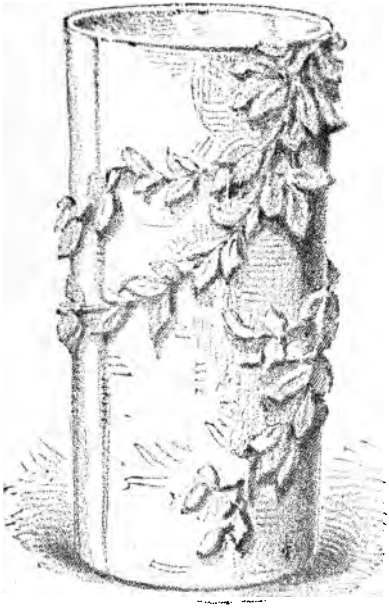


FIG. 48. Vase with Leaves and Flowers in Relief.

It is not the design of this section to enter into all of the details of painting necessary to enable the tyro to paint landscapes or flowers, but a suggestion or two in regard to the painting will not be out of place. The best results will be obtained by giving the vase two coats of white paint before attempting to lay on the color. The sides and border of the vase should be of a neutral tint, slightly mottled. An olive green or a gray looks well and gives relief to any design that may be chosen.

No attempt should be made to apply the colors

smoothly. The whole should be done in a bold, dashing way.

If painting is out of the question, some of the chromos before mentioned may be used with good effect. The edges of the chromos may be concealed beneath the pasteboard border. In either case after the paint on the article has become thoroughly dry and hard, which will probably require four or six weeks, it may receive a coat of pottery varnish, to be obtained at any of the color stores.

In the case of the applied artificial flowers, they should be heavily painted with, say four or five coats of white paint before applying the color.

Ornamental articles of this kind cost little save the labor, and will well repay the trouble of making.

IMITATION OF MAJOLICA

Cements and sealing wax are useful for giving to paper and wooden articles a hard glaze, resembling that of majolica ware. The cylindrical vase shown in the following engraving consists of a paper mailing tube 3 inches in diameter, and 6 inches long, furnished with a pasteboard bottom, which is glued in. The inside and bottom of the vase are provided with two or three coats of asphaltum or shellac varnish to render it waterproof. The outside is covered with jeweler's cement of different colors, or with sealing wax, or both. The bar of cement or wax is melted at the end, and applied to the paper cylinder in the same manner as it is applied in sealing packages. No particular care is required in applying the wax. It is, however, necessary that the edges of adjoining patches of wax be

... contact with each other to insure the complete covering of the paper. In the example shown in the engraving, olive green jeweler's cement forms the ... of the lower part of the vase. This is blended ... cement colored with Venetian red or Indian red, ... cement at the top is flecked with yellow.

... mass of cement is laid on in spiral lines, and ... covering is complete, the vase is held over a smokeless flame, such as that of a Bunsen burner or alcohol lamp, or it may be held over a coal fire until the cement fuses. The vase should be turned in such a way as to cause the variously colored cements to run into each other. The vase is held by means of a paper tube or a stick inserted in its open end.



Majolica.

Ornamentation may be applied by cutting leaves, stems, petals, etc., from pieces of thick paper, dipping them in melted cement of appropriate color, allowing them to cool, afterward ... upon the vase; finally softening the ... and the ornament by holding a flame ... them until the cement softens, and ... touched. Care is required at this

point to avoid the complete fusing of the cement, as this would spoil the job. Care is also required to avoid igniting the cement or wax, as it is nearly impossible to extinguish it.

STAINED GLASS AND OBJECTS OF WIRE CLOTH

A little stained glass work judiciously distributed imparts a bright and cheerful air to the house by introducing a few brilliant colors in a legitimate way, where they would be entirely out of place if introduced in draperies, carpets, or furniture.

It is an easy matter to make stained glass work after the more simple designs. It only requires a knowledge of the use of the glazier's diamond, or the very efficient

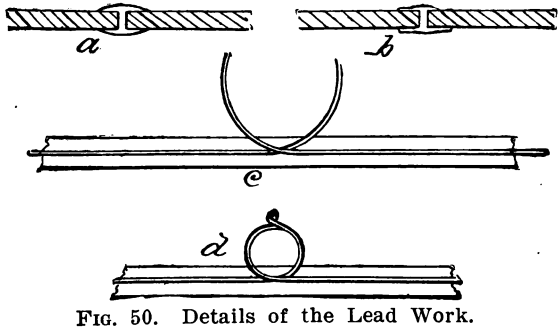


FIG. 50. Details of the Lead Work.

substitute for the same known as the roller glass cutter, and some proficiency in the use of the soldering iron.

The colored glass can be procured from almost any dealer, and for the grooved lead strips in which the glass is set, the amateur will have to depend on the stained glass works. Some manufacturers are willing

to furnish it in small quantities, while others are reluctant. It is to be regretted that there is no simple way of making these strips. Every stained glass manufacturer is provided with a machine by means of which he rolls them from larger strips of about the same form, made at the lead works, and known as cames.

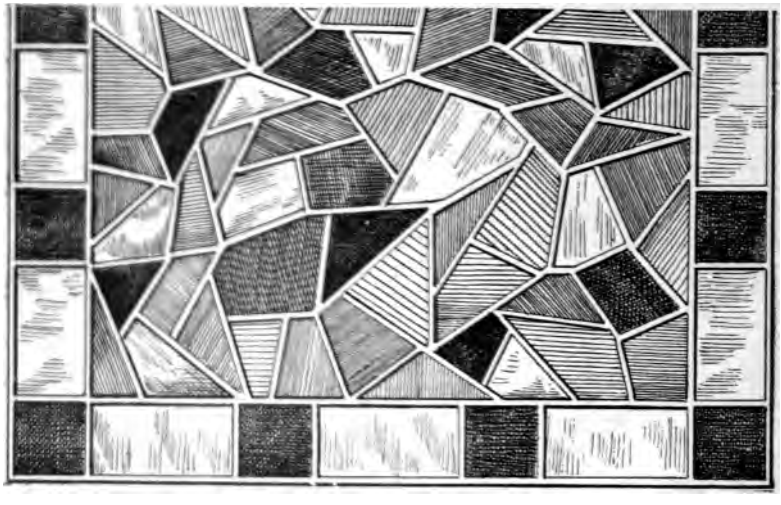


FIG. 51. Stained Glass Work "Crazy" Pattern.

Two kinds of lead strips are generally used in this kind of work, one of which is shown at *a*, in Fig. 50. This is narrow and convex, and well adapted for small curves, circles, etc. The other, shown at *b*, in the same figure, is wider and thinner and better adapted for straight work. At *c*, in the same figure, is shown the method of attaching copper wires to the lead for twisting around the rods which support the work, as shown at *d*.

A drawing of the pattern is made upon stout paper,

and the work is begun by cutting the glass according to the pattern, fitting the lead strips and soldering* them at their junction. After all of the glass pieces have been fitted and secured, the work is turned over and soldered upon the other side. The wires are then attached by first tinning them and then securing them by means of solder. These wires are twisted around

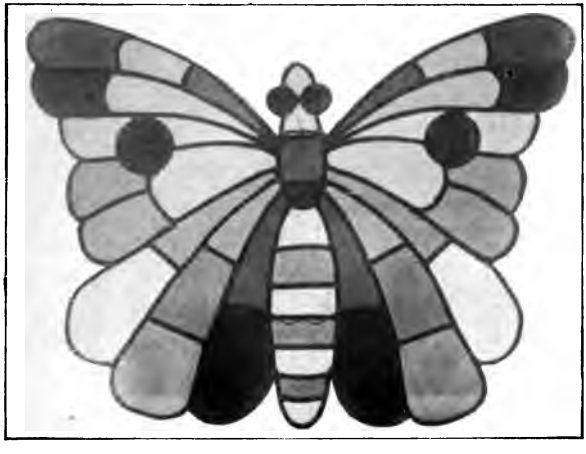


FIG. 52. A Leaded Glass Butterfly.

iron rods, which are so arranged as to support the work. Small pieces will not require the iron rods, but larger ones are liable to sag and buckle of their own weight. They are also apt to be blown out of shape by a heavy wind. The easiest pattern to produce on stained glass is that shown in Fig. 51. It is hardly worthy of classi-

* For the soldering, an ordinary soldering iron is employed, and common tinner's solder is used in fastening the joints. Tallow is used as flux. A tallow candle is commonly employed for this purpose. The joint to be soldered is rubbed with the end of the candle, and the solder is applied. Of course the iron must be well tinned and hot, and the touch of the iron upon the work must be very quickly and dexterously done.

fication among patterns, but it is pleasing if properly done. Some care is necessary to secure harmony of color, but there is little chance of failure in this kind of work.

It is a common practice to gild over the lead strips after the work is done, by means of gold paint, but it is a question whether it is any improvement over the natural color of the lead, especially in work exposed to the action of the elements. For some indoor work, such as fire screens, sash screens, lanterns. lamp shades, etc. the gilding is not objectionable.

The screen shown in Fig. 52 is not difficult. All of the glass pieces are of such form as to be easily cut, and the work of joining the lead strips is quite simple. As to colors, it would be well to follow the example of nature, or in any case to select such as will harmonize. It is hardly possible to produce more gorgeous coloring than is found among the butterflies. Green, blue, greenish-blue, red, yellow, brown, black and white (opalescent) are colors from which to select for this object.

The wire frame which supports the glass is carried along the lead strips and secured by solder. The antennæ are of wire. The base is of wood, neatly stained and polished.

A class of ornamental objects may be made from wire cloth which rival in beauty any kind of stained glass work. Figs. 53 and 54 are examples of this kind of work.

The wire cloth for this purpose should be made of fine wire, the mesh should be coarse, say 10 to the inch, and, moreover, the cloth should be painted and allowed to dry before the ornamental work is applied. The

wire cloth is supported a short distance from a design drawn on paper and the different colors are introduced into the meshes by means of an ordinary writing pen. A gelatine solution is used for this purpose. It should not be very thick, and it must be kept warm. Ordinary, transparent gelatine may be colored for this purpose by adding aniline. Colored lacquers answer ad-



FIG. 53. Lamp Shade.

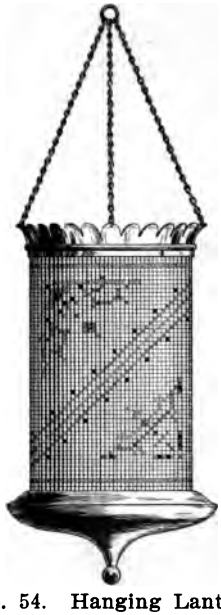


FIG. 54. Hanging Lantern of Wire Cloth.

mirably for filling the squares. Common white glue answers very well for filling the body of the design. The beauty of this kind of work and the simplicity of the method by which it is produced recommend it for many purposes.

The construction of the frames for the lamp shade and hanging lantern requires some mechanical skill.

Probably the aid of the tinsmith will have to be invoked in these cases. It will pay, however, as the articles will well repay the trouble and expense.

The hanging lantern, Fig. 54, is designed for a hall. It may contain a kerosene lamp, or the device known as the "fairy lamp," in which a large candle is employed as a source of light.

The colored checks in the wire cloth appear like gems when illuminated.

An experiment showing a phase of capillarity is illustrated by the annexed engravings, which give patterns.

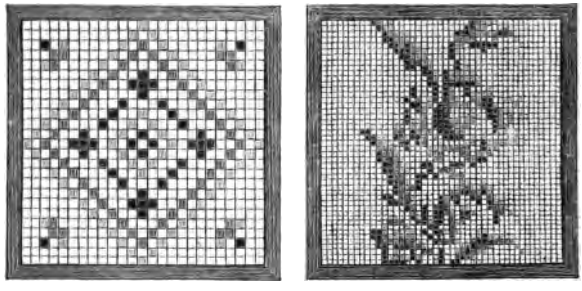


FIG. 55. Method of producing Designs on Wire Cloth.

This experiment was originally intended for illustrating tapestry and other designs formed of small squares, in colors, upon the screen; but it has another practical application, which is capable of considerable expansion. For projection, a piece of brass wire cloth, of any desired mesh, say from 12 to 20 to the inch, is mounted in a metallic frame to adapt it to the slide holder of the lantern, and the wire cloth is coated lightly with lacquer and allowed to dry.

The slide thus prepared is placed in the lantern and focused. The required design may now be traced by

means of a small camel's hair brush, colored inks or aqueous solutions of aniline dyes being used. The small squares of the wire cloth are filled with the colored liquid, and show as colored squares upon the screen. Different colors may be placed in juxtaposition without liability to mixing, and a design traced without special care will appear regular as the rectangular apertures of the wire cloth control the different parts of the design.

The colored liquid squares are retained in the meshes of the wire cloth by capillarity. A damp sponge will remove the color, so that the experiment may be repeated as often as desired. In this experiment the colored squares have the appearance of gems.

These designs may be made permanent by employing solutions of colored gelatine; but in this case the squares are so small that they are not very effective without magnification. Really elegant designs may be produced in this way for lamp shades, window and fire screens, signs, etc., as described above.

JAPANESE PORTIÈRE OR CURTAIN

There is a certain delicacy in a curtain made of long lashes formed of straw or bamboo and beads which is not found in a fabric of any kind. Curtains of this sort have been largely introduced into this country of late, some of them being simple, plain and cheap, while others are really very elaborate and, of course, correspondingly expensive. It is a very simple matter to make a curtain of this class, provided the materials are at hand; but where neither bamboo nor straw nor beads are available, it becomes

more difficult. But a very presentable curtain may be made from paper, which is obtainable everywhere. The large engraving shows a very simple pattern made of straws of different length, and glass beads of different colors, strung on strong thread or fine strong twine.

The first thing to be done toward making the curtain is to draw a design roughly on a sheet of paper, then tie a thread in a bead which is to form the finish of the lower end of the lash. Then the bead is

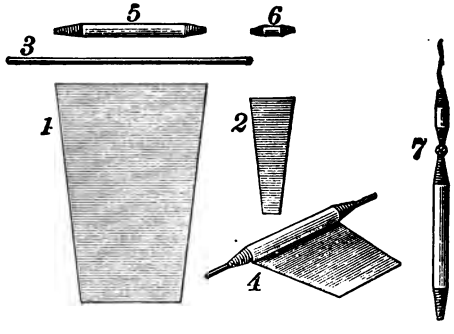


FIG. 56. Method for making Paper Rolls.

fastened in its place on the pattern by driving an ordinary pin through it into the board or table beneath. The stringing of the straws and beads is thus proceeded with according to the requirements of the pattern.

When one lash is finished, its upper end is fastened on the design by an ordinary pin driven through a knot tied in the thread. The next lash in order is proceeded with in the same manner, and so on until the entire series of lashes is done. A stout string is

stretched along the series of pins by which the upper ends of the lashes are secured. Each thread is then tied around the transvere string. If desired, the threads may be spaced by beads arranged on the string between the lashes. As all the knots are necessarily trimmed close, it is well to touch each knot with mucilage. When this is dry, the curtain is finished.

A very handsome curtain may be made from beads alone, or from beads and plain uncolored straws, or the straws may be dyed different colors by means of aniline dyes, or by dipping them into thin colored lacquers.

A curtain or portière of bamboo and beads is made in the same way, but on a larger scale.

It is easy to make a good imitation of these curtains with paper tubes and beads, or the tubes alone. The manner of making these tubes is shown in Fig. 56. The paper from which the tubes are made should not be thicker than common writing paper. It may be either colored or white. The best results will be secured by using common white writing paper and coloring the tubes after they are formed and dry, by means of thin brown or white shellac varnish, colored with pigments or the anilines.

The pieces of paper from which the tubes are made are preferably cut in trapezoidal shape, as shown at 1 and 2, so that when the tube is finished it will have conical ends, as shown at 5, 6, and 7. The wire shown at 3 is used as a mandrel upon which to roll the paper. The larger end of the piece of paper is applied to the wire when the paper is rolled up in the manner illustrated at 4. The narrower end of the paper is gummed and pressed down closely, when the wire is removed

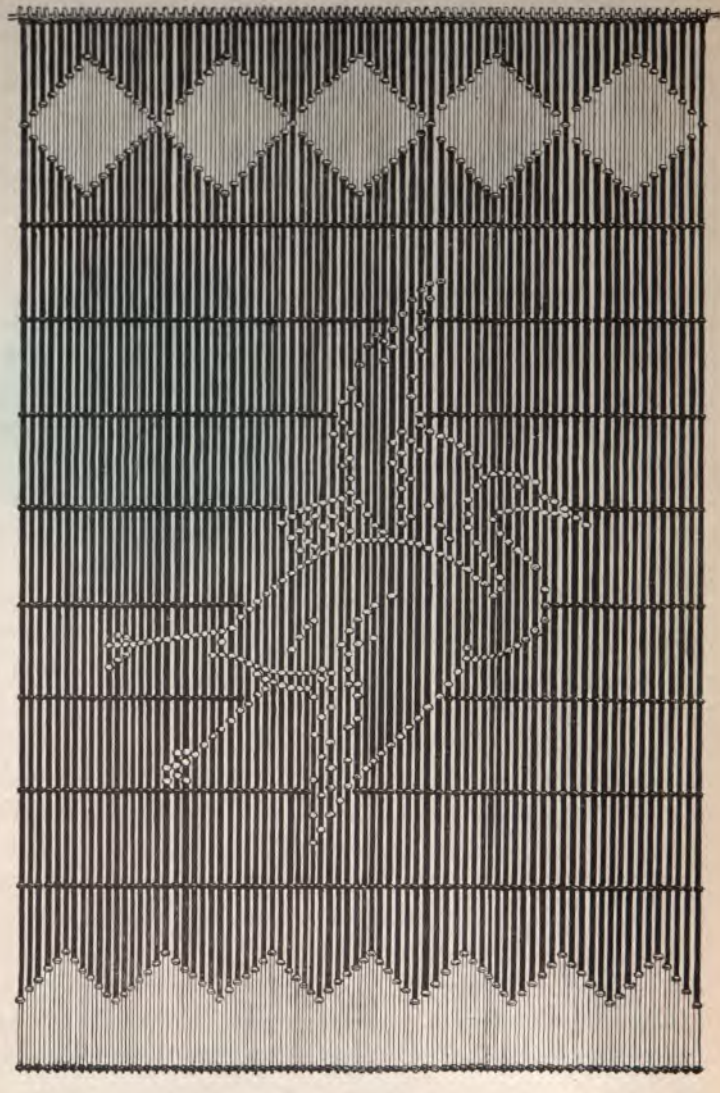


Fig. 57. Curtain formed of Straw, Bamboo, or Paper, and Beads.

and the operation is repeated. It is not advantageous to gum the entire surface of the paper. Fastening at the end is sufficient. The wire used as a mandrel should not be more than one-sixteenth inch in diameter, as too large a hole through the rolls allows them to arrange themselves irregularly. At 7 is shown a part of a lash formed of a long tube, a bead, and a short tube.

In stringing both the straws and the paper tubes a long slim needle will be required. If this is not obtainable, a very good substitute for it may be made by forming an eye or loop on the end of a thin wire of suitable length.

There is scarcely any limit to the amount of labor that may be expended upon an article of this kind; but very pleasing results will be secured by the adoption of simple designs, which may be easily carried out.

REPOUSSÉ

This art, as practiced by the silversmith and the artist, is almost entirely dependent upon the manual dexterity of the operator. A kind of repoussé is here suggested which depends more upon appliances than skill. It is not, however, assumed that any set of devices can be made to serve in lieu of taste and judgment.

To carry out this method, a piece of heavy cotton lace, or heavy open work fabric, or a piece of a basket may be glued to a block of hard wood to serve as a sort of die for producing the impression in the metal. The fabric or basket work is not only attached to the block by means of glue, but its finer interstices are filled with glue so as to present a surface resembling the original fabric only in the most general way.

When the glue is perfectly dry and hard, the die is laid upon a solid foundation, and a piece of very thin, soft copper or brass is secured to the block so

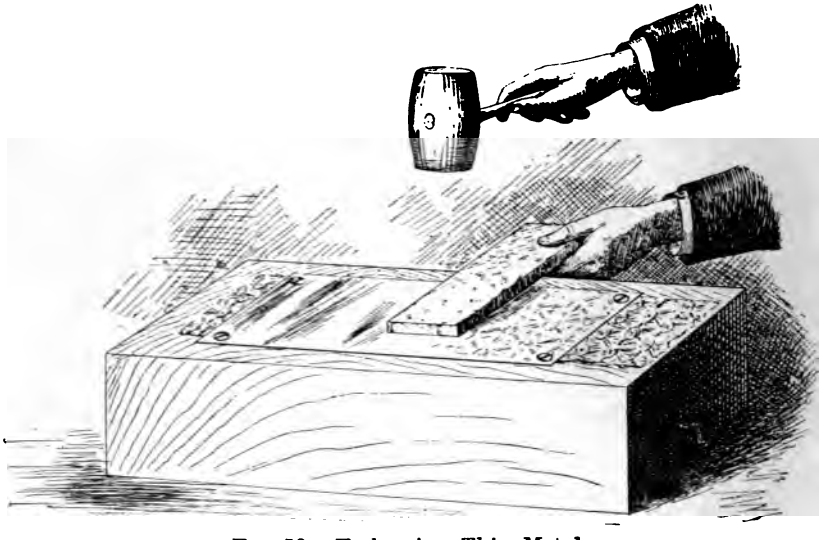


FIG. 58. Embossing Thin Metal.

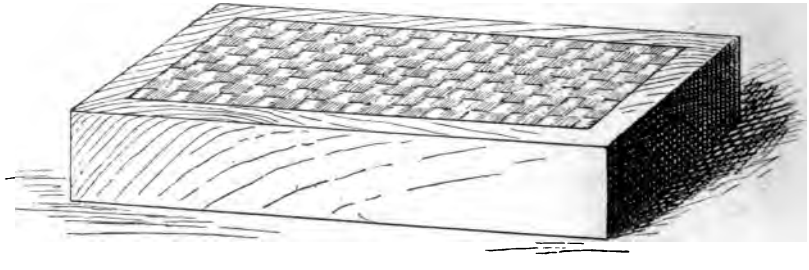


FIG. 59. Basket Pattern.

as to cover the lace as shown in Fig. 58. A piece of cork, about $\frac{1}{4}$ inch thick, and about three inches wide and 6 or 8 inches long, is laid over the metal and

struck with a mallet, as shown. The cork yields sufficiently to push the metal down upon the die, and cause it to take the pattern of the lace or whatever is used in forming the die. A piece of rather hard rubber packing will answer this purpose equally as well as the cork.



FIG. 60. Die formed of Pasteboard.

Designs may be cut from strong paper or pasteboard, and glued to the block. Fig. 60 shows a design which may be reproduced in this manner.

In Fig. 61 is represented a stencil design to be sawed

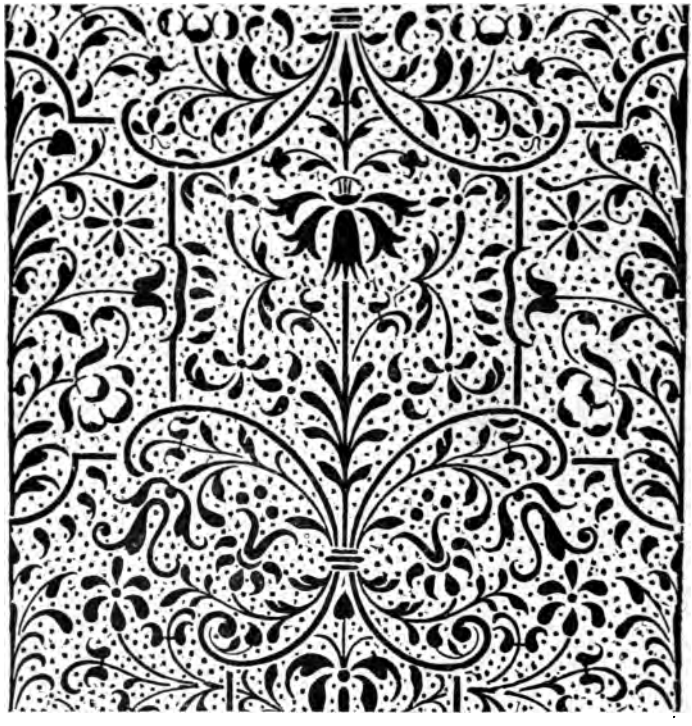


FIG. 61. Stencil Pattern.

from hard wood. The lines and scrolls are discontinued in places so as to cause the wood to hold together. If it is desired to render the lines continuous at these points, they may be run through with a V-tool. The dots are picked out with a small gouge or

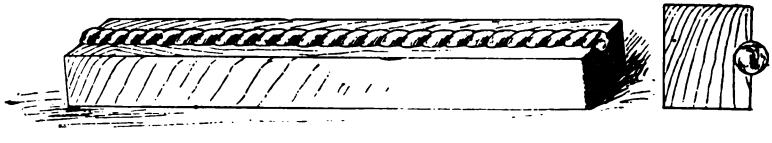


FIG. 62. Rope Pattern.

the point of a revolving drill. In all these cases the metal is attached to the block and treated as shown in Fig. 58.

In Fig. 62 is represented in side elevation and in section a die formed of a small rope, glued in a semi-circular groove in a bar of hard wood. The embossing is done in the manner before described. In this case a thick piece of soft rubber is preferable to cork for forcing the metal into the depression of the die.

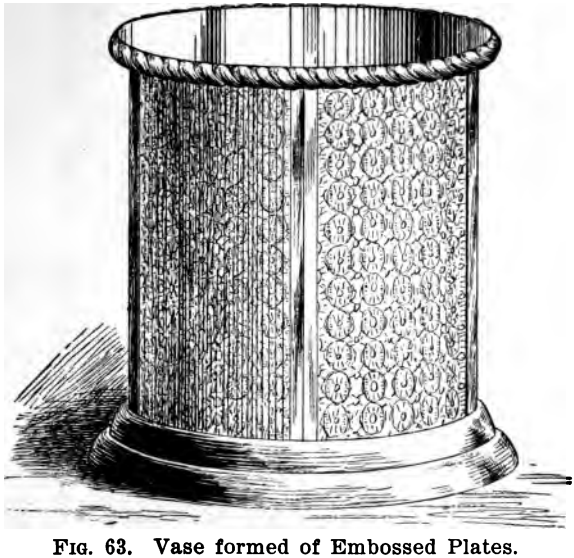


FIG. 63. Vase formed of Embossed Plates.

Either panels or continuous strips may be embossed in the manner described, and these are to be used in making frames, vases, and various ornamental objects. If the metal is too thin for a certain case, it may be strengthened by flowing soft solder over the back of the plate by means of a soldering iron.

The vase shown in Fig. 63 is formed of four embossed

plates of copper, fastened to the back of four vertical brass strips by solder, the whole being secured to the bottom piece in the same manner. The bottom consists of a disk of copper soldered in. The base is formed of a brass stove-pipe collar soldered to the lower part of the body of the vase. The rim around the top consists of a strip embossed on the rope die.



FIG. 64. A Bas-relief in Lead. Copper, or Brass.

As to finish, any of the usual methods of brass finishing should be employed. This vase is especially adapted for containing a palm or other large foliage plant. The earth and roots may be placed directly in the vase or they may be contained by a pot which is enclosed by the vase.

It is obvious that vases of other forms and other embossed designs may be made on this plan.

Bas-reliefs may easily be made by a method which is a modification of the one described. Fig. 64 shows such a relief, and Figs. 65 and 66 illustrate the tools required for making it.

To the wooden frame, A, is fitted a board, B, upon



FIG. 65. Frame and Form for making the Bas-reliefs.

which is drawn in outline the design which is to be produced in relief. The board may be of pine or any close-grained soft wood for lead work; but for brass or copper, the wood should be hard. To the frame, A, is attached the plate of metal by means of screws.

The board, B, is removed from the frame, and the

portion of the design which is to form the most prominent feature of the relief is sawed out of the board, when the latter is replaced in the frame, and the metal is forced into the opening of the board by pressing upon the surface of the lead opposite the hole in the board, or by pounding it by means of the mallet, C, shown in Fig. 66. As soon as this feature is complete, the next in order is sawed out of the board, and the operation is

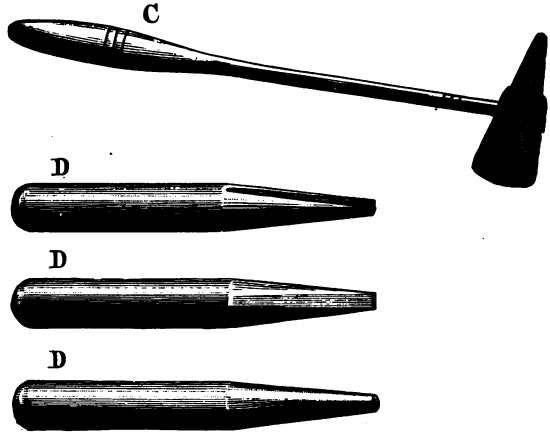


FIG. 66. Tools for Repoussé.

repeated until all of the general features are developed. The progress of the work can be observed at any time by removing the board, B.

The features may be corrected or modified by working from either side of the plate by means of the convex mallet and the wooden punches and chisels, D (Fig. 66). If a support is desired for any part while the work is progressing, a stout bag filled with sand may be placed under the part. A few very small bags,

say 1 inch or 1½ inches in diameter, will be found convenient. If desired, the drapery or the background may be chased by means of hard wood or metal punches, bearing on their faces the desired figures.

The relief, if of lead, looks well with an antique finish.

AN EASY METHOD OF PRODUCING BAS-RELIEFS

The production of patterns from which to cast ornamental articles is confined to a class of artisans who, by long experience in carving and modeling, have attained great excellence in workmanship. An amateur, while he may not hope to attain such excellence, and



FIG. 67.

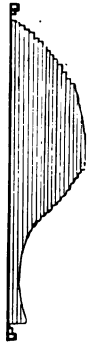


FIG. 68.

Bas-reliefs in Wax.

cannot expect to produce, by the usual processes and with limited practice, such exquisite articles as may be seen in many of the city shop-windows, may, if he possesses even a modicum of artistic taste and skill, do something in that direction.

The articles required to carry out the process are some thin sheets of semi-transparent wax, a knife having a narrow, dull blade, and the printed or drawn design of the form to be produced. The backing, or surface on which the relief is made, may be of any of the materials of which patterns are commonly made.



FIG. 69. A Scroll Design.

Having given the backing the required form and located thereon the position of the relief, a sheet of wax is laid over the design and the extreme outline of the figure is traced on the surface of the wax with a dull point. The wax is now laid upon a smooth board and cut upon the line just made with the knife, the blade being slightly warm. The wax thus cut is now placed

on the foundation or backing, and fastened by heating the knife blade quite hot and touching the wax at several points, so as to cause it to melt and adhere to the

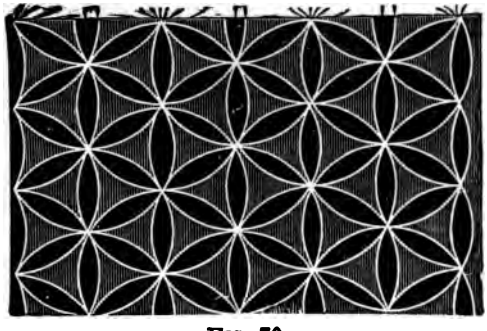


FIG. 70.

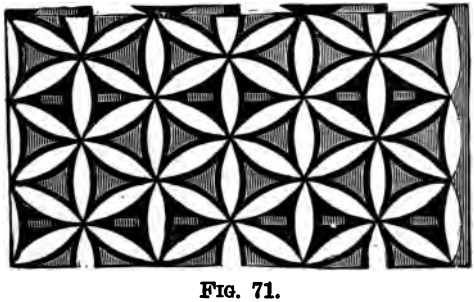


FIG. 71.

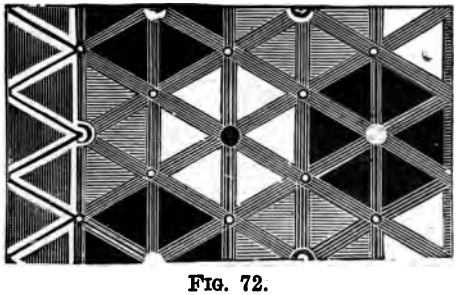


FIG. 72.

Patterns for Bas-reliefs.

backing. Supposing this piece of wax to have the thickness required in the thinnest portion of the relief, another sheet is laid upon the design and traced within, and a small distance from, the outline of the design. It is cut and laid upon the first piece and made to adhere by pressing it down slightly.

Another sheet of wax is traced within the outline of the second, and cut and placed upon the two already secured to the backing, and so on until the design is produced in what might be termed the *rough*. This stage is illustrated in Figs. 67 and 68, which are respectively front and edge views, which give the idea of the arrangement of the several sheets.

After the sheets are placed upon one another in the manner first observed, the edges may be burnished down by the rounded back of the knife, or by any smooth, rounded implement, which must be slightly warmed.

Superfluous wax may be removed by scraping when cold, and indentations and interstices may be filled by adding a little wax. A scroll design is shown in Fig. 69.

When the model is to be reproduced in metal cast in sand moulds, the wax should be slightly varnished with pattern varnish; but when the design is to be produced in plaster, a mould of plaster may be taken from the model after it has been oiled.

A bas-relief may be made in this way from a profile photograph or from an engraving.

The process may be employed to advantage in ornamenting patterns for the coarser and heavier kinds of work.

Figs. 70, 71, and 72 represent surfaces ornamented in this manner.

ORNAMENTAL IRON WORK FOR AMATEURS

Although artistic wrought iron work dates from very early times, it was never more popular than it is at present. This remark applies especially to movable

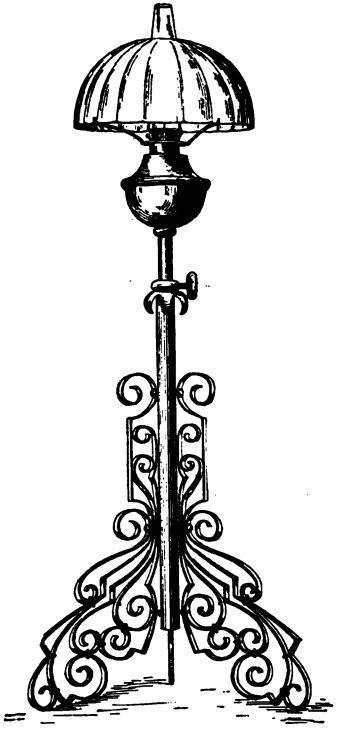


FIG. 73.



FIG. 74.

Iron Lamp Supports.

articles such as tables, stands, racks of various kinds, fuel baskets, lamp supports, etc. Many of these articles of recent manufacture are copies of antique objects, while others are of modern design. As works of

art they are fully equal, if not superior, to the specimens of earlier work.

Now, while no imitation can ever equal the original article, it must be admitted that imitations often prove very satisfactory to those who can neither make nor purchase the real article.

The examples of iron work here illustrated are styled imitations, as they are made without forging, *i. e.*, the iron is bent either cold or hot, without the use of a hammer, while the iron bars or rods maintain their original cross section. Any one used to the hammer and anvil can, in addition to the curves, apply forged portions, or twist and forge the bars used in the scrolls.

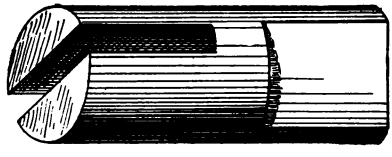


FIG. 75. Jaw for Bending.

The only special tool used in making articles of this class is the steel jaw shown in Fig. 75. Its slot receives the bar to be bent, and its flattened shank is designed to be held in an iron vise. A scroll is formed by placing the end of a bar in the jaw, and winding the bar around the jaw and upon itself, afterward unwinding the bar to open the spiral as much as may be required. After the scroll is complete, the inner straight end of the bar is cut off by means of a hack saw. The sharp angles may also be bent by the use of the jaw. It will facilitate the operation if the bar is heated red hot at the point of bending. A hammer may prove useful in this part of the operation.

The standard of the lamp support consists of a piece of gas pipe. The feet are attached by means of screws, and the different parts of the iron work are fastened together by means of small screws or bolts.

A rod is fitted to the gas pipe and has at its upper end a frame or cup for receiving the lamp. A clamping screw passing through the gas pipe holds the rod at the desired height.

An easy and satisfactory way of blacking the work after it is finished is to coat it with a thin varnish of stick or seed lac cut in alcohol, with refined lampblack stirred in to give it the required color. The varnish should be made quite thin to avoid any gloss, and should be strained through cheesecloth or similar material.

It is obvious that grilles, gates, screens, doors, and other objects may be made from iron in this way with little trouble or expense.

SOME THINGS IN WIRE

There is scarcely a limit to the number of useful and ornamental things that can be made from wire. Two examples are shown in the engravings, Figs. 76 and 77, representing respectively front and edge views of a newspaper and magazine holder formed of a wooden back and wire scrolls; Fig. 78 showing a small wire stand or card receiver having a zylonite top.

The scrolls of the newspaper holder are formed of three-sixteenths inch square brass wire; the several pieces being bent in the form shown and held in place by clips of the same material soft-soldered by means of a blowpipe. The overlapping portions of the scrolls

are also soft soldered. The lower part of each main scroll is held by a strong staple passing over the wire of the scroll and through the cleat and backboard and clinched on the back of the board. The three wires at the center of each scroll are prolonged below the cleat, as shown, to form a stop for limiting the swing of the scroll.

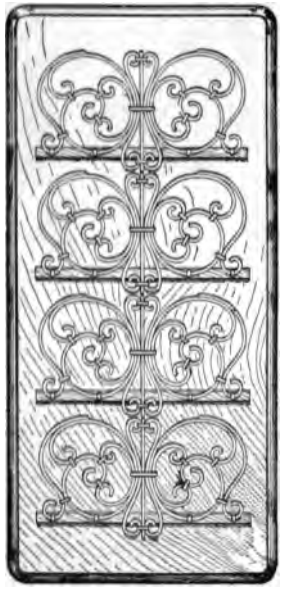


FIG. 76. Newspaper Holder.



FIG. 77. Edge View of Newspaper Holder.

If care is taken in soldering the clips, the brasswork will require little preparation for lacquering. A stiff brush charged with finely powdered pumice wet with water and applied vigorously to the work will quickly remove all stains, and will give the work a uniform ap-

pearance. The backboard, which may be of walnut, mahogany, cherry, oak, ash, or maple, should be varnished and well rubbed down before the cleats are applied.

A holder of this kind will receive a large number of periodicals.

The wire stand or card receiver, shown in Fig. 78, is

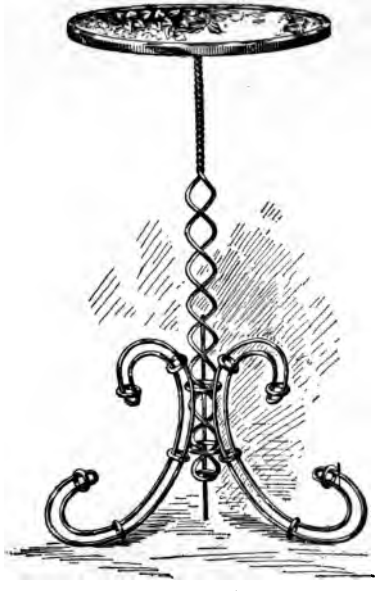


Fig. 78. Wire Stand or Card Receiver.

made of one-quarter inch or three-eighths inch round brass wire. It may be made of brass tubing three-eighths inch or one-half inch outside diameter and rather thick. In this case the tubes are annealed and filled with lead before bending. The lead is melted out

of the tubes after bending. The spirals are formed separately by wrapping the tube or wire around a cylindrical bar of wood or iron in a close helical coil, then stretching out the coils, placing them together, as shown. They are then clamped on a smaller cylindrical bar and their upper ends are twisted together. Two rings surround the lower part of the spiral and to these rings are secured the legs by means of solder or screws.

The small rings surrounding the legs may be purchased and secured in place by solder.

The top of the stand consists of a disk of wood, concaved at the top and furnished with an embossed disk of zylonite.

The under surface of the stand top is provided with a perforated block, which fits over the closely twisted end on the standard. This receiver may be made so small as to stand upon a table, or it may be made of the usual table height.

SOME THINGS IN BURNISHED BRASS

The old and commendable fashion of making ornamental objects from solid hand-wrought metal is being revived to a wonderful extent. Steel, iron, brass, and copper are wrought into a thousand beautiful and useful forms, and the gilded and tinsel objects of recent days are now set aside for substantial and elegant solid cast and hand-wrought ornaments. It will require only a suggestion to set the amateur mechanic at work at this sort of thing, when his dwelling will soon be adorned with articles that will be the more valuable for having been produced at home.

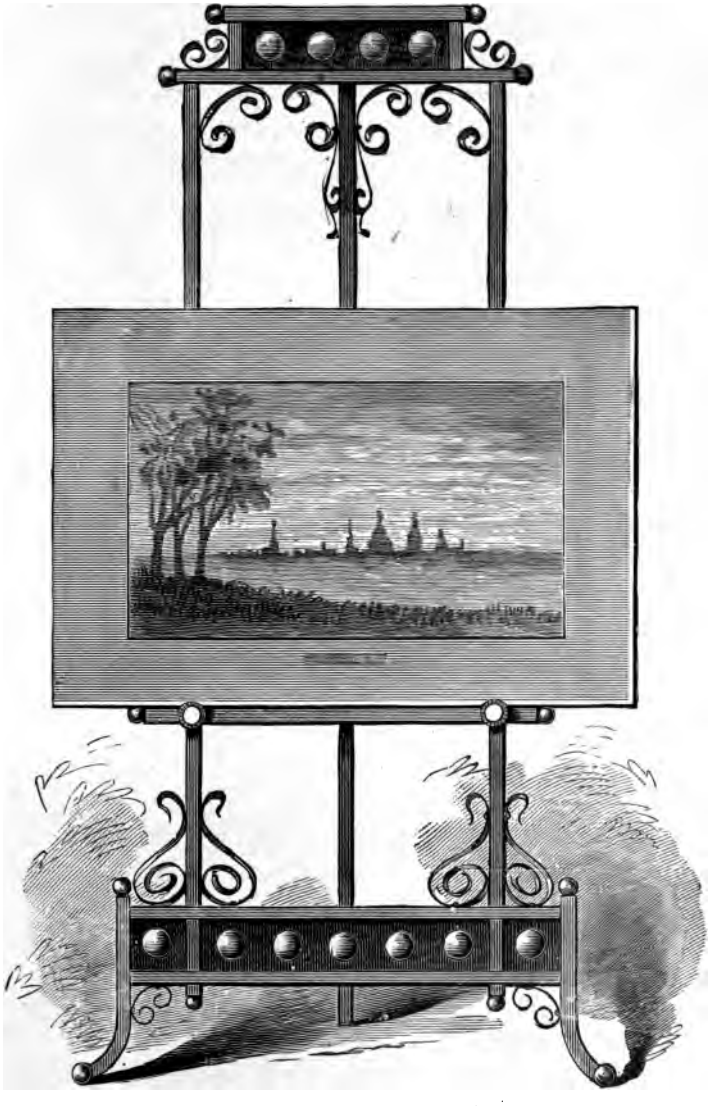


FIG. 79. A Brass Easel.

Brass tubing and rods of round, hexagonal and octagonal section, plain and perforated strips of different widths and thicknesses, half round and semi-hexagonal strips, and brass buttons, knobs, and nails of various shapes, may be purchased so that the amateur will



FIG. 80. A Brass Frame.

readily find available materials for the kind of work suggested. Half-inch square tubes, strips of brass half an inch by one-sixth of an inch, a few brass buttons, and a few knobs, are required for the easel shown in

Fig. 79. The tubes may be draw-filed, then finished with the different grades of emery paper with oil, or they may be polished on an emery wheel, and the final finish may be imparted by using the finest French emery paper with oil.

When two tubes cross each other they may be halved



Fig. 81. A Nautilus Card Receiver.

together precisely as in wood work, and may be fastened by soldering with soft solder.

When the end of a tube abuts against the side of another tube it may be fastened solid enough for all practical purposes by soft soldering by means of a blowpipe. Of course the joint may be brazed or sol-

dered with silver solder, but as great strength is not required, it is unnecessary to take that amount of trouble.

A very good way of fastening is to solder a plug in the end of the tube that abuts against the side of another tube, and to put a screw laterally through one into the plug in the other. In this case it is well to leave a slight feather on opposite sides of the abutting tube

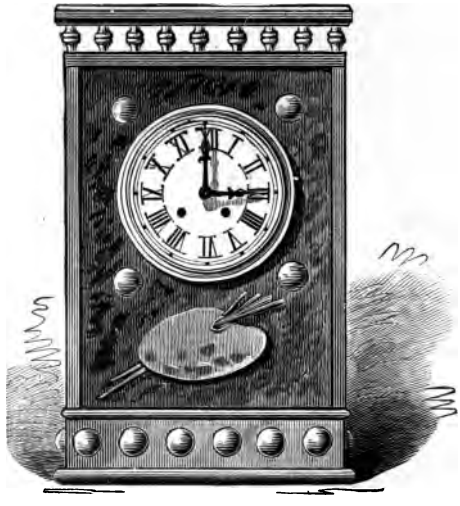


FIG. 82. A Brass Clock.

to engage the corners of the tube to which it is attached.

The scrolls should be attached by means of small screws. The panels consist of thin pieces of board covered with velvet or plush of any suitable color. They are inserted from the back, and are provided with a number of large convex nails. The support for the picture is movable up and down on the side pieces of the

easel, and may be secured at any desired point by the milled screws.

The frame shown in Fig. 80 will require no special description. The main portion of it is made of square brass tubing. The side bars are made of round brass

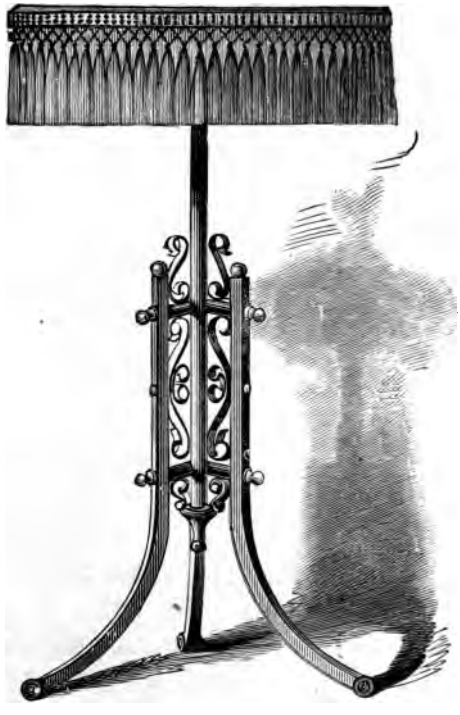


FIG. 83. A Brass Table.

rods with turned end pieces, as shown. The mat of thin wood is covered with velvet or plush. The picture and glass are placed behind the mat; the latter is provided with small brass ears which are fastened to the back of the frame by screws. The knobs at the top,

bottom, and sides of the frame and easel are turned and attached with solder.

Fig. 81 shows a tripod stand for a nautilus shell, with an ornamental shell placed below it in the center of the plate, forming the triangular base. Fig. 82 shows a clock case, consisting of an ordinary box of suitable size covered with plush or velvet, and inclosed in a frame of brass.

The frame is built up in the manner already described from square brass tubing split lengthwise through diagonally opposite corners. The lower por-

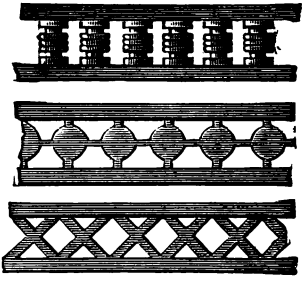


FIG. 84. Examples of Paneling.

tion of the frame consists of a wide band of brass, having a light bead soldered to its upper edge and a heavy bead soldered to its lower edge. A number of the brass nails are placed at regular intervals and soldered at the back of the brass base. The rail at the top is made of hexagonal brass tubing, and the small balusters are turned from brass rods. The palette and brushes are sawed from a plate of brass and attached by tacks soldered to the back. The patches of color are produced by different colors of sealing wax. Four brass nails are inserted around the dial to relieve the blank

spaces on the plush. The clock and its plush-covered case may be removed from the brass frame when it is desired to clean the latter.

The table shown in Fig. 83 is of the same general character as the other articles, and will not, therefore, need particular description. The central portion is of three-quarters inch round brass tubing. The legs are of five-eighths square brass tubing. The top is of wood, plush-covered and fringed, and provided with a border of perforated brass.

Fig. 84 shows different kinds of panels. The balusters in the upper one are turned; in the two lower ones they are cut from sheet metal.

All of these articles may be lacquered, but they present a more elegant appearance if the metal is left unprotected and cleaned occasionally with rottenstone and oil.

There is hardly any limit to the number of pretty and useful articles that may be made of such materials, with the expenditure of little thought and labor.

FORMING PLASTER OBJECTS

It is sometimes convenient to form objects of circular section from plaster of Paris. This is a very simple operation, requiring only very simple tools and apparatus. An iron rod, bent at one end to form a crank, and carrying a conical wooden roller, two notched bars of wood for supporting the iron rod, and a pattern made from a thin piece of hard wood, comprise the outfit for making these articles. The rod is held in its bearings in the bars by pins inserted obliquely in holes in the wood, so as to project over

the rod. The pattern is cut so that its edge is a profile of one side of the article to be made. The wood should be made thin on the working edge. The patterns may be made to advantage of metal backed by wood.

The conical wooden roller should be flattened on three or four sides to prevent the plaster from turning around on it. The roller is oiled or smeared over with grease, and a batter of plaster of Paris is prepared by mixing the dry plaster with water to the consistency of cream. As soon as the plaster begins to set it is applied plenteously to the roller, and while the rod is turned

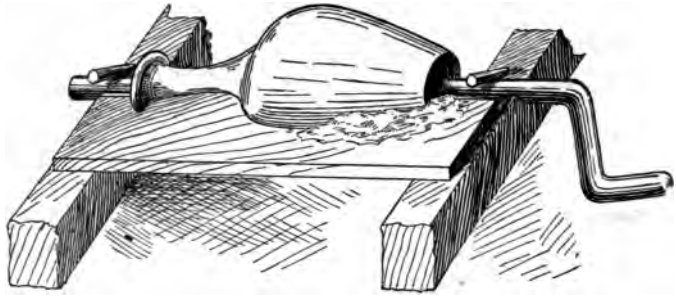


FIG. 85. Forming Plaster Objects.

by means of the crank the pattern is moved forward toward the rod, and the surplus plaster is removed by the pattern which acts as a scraper. Any deficiencies are supplied by a new application of the batter.

When the object is of the right size and form, the pattern is removed and cleaned, and again applied to the object, the latter having been brushed over freely with water. This gives the finishing touch.

After the plaster becomes perfectly dry and hard, the roller is knocked out, and the object is subjected to

a dry heat at a temperature of about 212 degrees Fahr. for an hour or so. It is then brushed over with thin glue size until it has absorbed as much as possible, when it is allowed to dry for several days. The latter treatment renders the plaster hard and strong.

The final operation consists in painting, lacquering or bronzing the object, as taste may dictate.

PART III.

METAL WORKING

SAWING METALS

A GREAT DEAL of hard labor in working metals may be avoided by the use of hack saws and jeweler's saws. The large hack saw has a malleable iron frame and a handle and tail piece which will revolve so as to adjust the saw to any desired angle. The tail piece has an adjusting screw by which the tension of the saw may be regulated. Several kinds of saws can be used in this frame, *i. e.*, saws with coarse and fine teeth, which are set more or less according to the kind of metal on which they are used. These saws all have very hard teeth, but the main portion is soft, so that the saw does not readily break. These saws are cheap, and when one becomes dull or is broken it is replaced by another. They are so hard they cannot be filed.

The next saw in size has a heavy wire frame. Slits are cut in opposite ends of the frame to secure the saw, and small pins extending through holes in the ends of the saw rest in notches cut in the frame. The spring of the frame holds the saw under tension. To put in a new saw, the ends of the frame are sprung inwardly with considerable pressure. The saws for this frame are also hardened on the toothed edge, the remainder being soft. They are much thinner than the large saws.

The smaller saw frame is adjustable as to length and is designed to receive very small saws made from material like watch springs.

This saw is for more delicate work than the others. No attempt is made to sharpen them with a file. A dull one is thrown away and replaced by a new one.

There are many kinds of work in which a great deal of time and labor may be saved by the use of these saws; for example, cutting off iron, steel and brass bars and tubes, cutting various straps out of thick sheet brass; cutting slots in work when required. They may also be used in place of files in places where a file cannot be introduced.

SOLDERING

Nothing is more useful for the amateur than a knowledge of the art of soldering. It is a very simple one,



FIG. 86. Articles used in Soldering.

the tools required are inexpensive, and there is real satisfaction in doing it rather than being delayed to employ a regular tinsmith or other mechanic.

The soldering iron consists of a small oblong block of copper, pointed at one end and having a large wire screwed into the other end, the wire being provided with a wooden handle. Some soft solder will be required, say a quarter or half pound. It is better to buy

this in the form of solder wire, but it can be readily made by melting together equal parts of pure tin and pure lead.

To carry on the work a small box of pulverized rosin and a bottle of soldering fluid will be required.

The soldering fluid can be purchased. It is readily made by filling a small bottle half full of hydrochloric acid. (This acid must be handled with care as it is poisonous and very corrosive.) Into the acid drop little strips of zinc, a few at a time, until it will dissolve no more. This operation must be done in the open air, as the fumes are suffocating and injurious. When the boiling of the acid ceases the bottle should be filled up with water and closed with a rubber stopper. In addition to these things already mentioned a small tin box containing a wet cloth will be required.

Before soldering can be done the copper must be heated so that it will melt the solder readily. Then the pointed end must be cleaned with a file and a piece of the solder wire is dipped in the soldering fluid. When the end of the wire wet with the fluid is placed in contact with the side of the hot soldering iron it will melt and the soldering fluid will cause the solder to adhere to the copper. This may be repeated until the four sides of the pointed end are covered with solder, or "tinned" as the smiths have it.

To solder, the joint to be made is scraped clean; then a very small amount of the soldering fluid is applied if the work to be soldered is iron or copper, or brass, but if it is bright tin a little of the rosin will answer rather better than the acid. The iron is to be heated, not too hot, however, then quickly wiped on the damp cloth and applied to the solder, to take up a drop, then

placed on the joint and moved slowly along, allowing the solder to follow. If the tinning is burned off the soldering iron, it must of course be retinned. The secret of success in soldering is to have the iron just hot enough, and to have the surface to which the solder is applied very clean.

GRINDING AND POLISHING

Removing surplus metal by grinding, sharpening tools, and smoothing and finishing work are most readily accomplished by the amateur by means of emery wheels of various degrees of fineness, or corundum or carborundum wheels used in the lathe. If a fine lathe is available, the wheels may be carried by suitable steel mandrels mounted between the lathe centers, or by a single mandrel held by a chuck; but when these things are not available, the wheels may be mounted on a hard wood mandrel. The mandrel has a shoulder against which the wheel is clamped by a wooden collar, and a pin or key passing through a hole in the mandrel. Washers of leather or pasteboard may be used to adapt the mandrel to emery wheels of different thicknesses. In selecting an emery wheel, one should be chosen which will cut freely without glazing. Such wheels revolved in a lathe cut rapidly and serve well for removing surplus metal and for sharpening tools. A rather fine wheel is preferable to a coarse one for the latter purpose.

For polishing, a wheel may be made of a disk of wood turned in the lathe and covered on its periphery or side or both with leather. Sole leather which contains no oil or grease is the best for the purpose. If the leather-

covered wheel is not true it may be turned off in the lathe and smoothed with fine sandpaper. The leather on the edge of the wheel should be scarfed and lapped so as to make a smooth joint.

After the leather is properly finished it should be coated with emery of the degree of fineness required. This is done by warming the wheel, coating it with strong glue and rolling it in the powdered emery. To insure a good job, the emery itself should be warm. Probably the best way to secure good results is to spread the emery out on a flat metal plate which has been heated. The leather-covered wheels are very useful. They may even be used in place of the solid emery wheel in many kinds of work. If they are used carefully they will last a long time After one is partly worn it is even more useful than it is when new. For polishing steel a leather-covered wheel of the kind described charged with crocus instead of emery will be required, also another charged with fine rouge or putty powder for a very fine finish. For buffing silver and other soft metals a wheel of chamois skin or buckskin drawn over a padding of soft felt and tacked at the sides of the wheel will be found valuable. The skin will have to be lapped on the periphery of the wheel, but it cannot be glued. Fine rouge is the best to apply to this wheel. For polishing irregular surfaces bristle brushes must be used, a coarse brush charged with powdered pumice stone for doing the rougher work; this to be followed by a finer brush charged with tripoli or whiting and water.

The brushes, which have wooden hubs, are carried by tapering screws held in the lathe chuck or inserted in the mandrel in place of one of the centers.

SILVER WORK

Silver is not a very expensive material for the manufacture of small objects, and it is easily worked and finished. The objects when finished have an intrinsic value, and if the effort to produce a fine article results in failure, the material is not lost; it can be sold as old silver, with little loss.

The engraving shows articles which an amateur can make. The bonbon dish and spoon shown in the illustration were quickly made by an amateur silversmith.



FIG. 87. Examples of Silver Work.

It is first folded in the center, then opened and folded at right angles to the first fold; then opened and folded again parallel with the first fold, and so on until the entire surface is crossed with folds about three-fourths of an inch apart. The edges are turned up all around for about $\frac{5}{8}$ of an inch, and the corners are crimped a little, and small folds are made. The whole work up to this point can be done with the fingers alone. The folds at the corners are hammered down

with a wooden mallet while the sheet rests at the corner on a round support. From time to time the silver should be annealed, *i. e.*, heated to a low red heat, and plunged into cool water. This will permit of bending the silver without breaking it.

Little folds should be made in the sides at the upper edges if necessary, to allow the sides to be straightened; then the upper edge should be trimmed off with shears, so that the dish is the same height all around. Then a piece of hollow silver wire which has not been soldered is opened slightly at the seam by drawing a knife through the seam. A piece of this wire long enough to reach around the upper edge of the dish is slipped over the upper edge of the dish and soldered at different points, with silver solder. If this is not within the power of the amateur, he may attach it at frequent intervals by means of very small pieces of soft solder melted after the application of a very minute quantity of soldering fluid, by holding the edge of the dish with a pair of pliers over a gas flame two or three inches above the top of the flame. If this is carefully done, the small particles of solder will soak into the joint and become invisible. Across the corner of the dish is secured a tree limb made of silver, and on this are secured the birds. The silver limb is made by hammering a stout silver wire into a half-round notch in the end of a piece of steel, grooves being formed in the notch to give the flattened wire the appearance of having bark on it. The birds are of special make, used for other purposes. If the amateur silversmith desires to use the birds he will be obliged to purchase them, as they cannot readily be made by one having no experience in this line. They are of bronze and are colored.

This particular dish was oxidized before the birds were applied. The dish was oxidized by immersing it for a few minutes in a solution of bisulphuret of soda. It was then washed and dried and the oxide was removed from the projecting portions by means of a chamois skin charged with rouge. This dish may readily be made round, elliptical, or triangular, as taste may indicate. It is well in a case like this to try the experiment of making the dish in copper or soft brass before trying silver.

METAL FOOT LATHE

The amateur after using the simple wooden lathe will no doubt ask for something more pretentious, a lathe that can be used for working metals in various ways, and drilling and turning hard wood, horn, ivory, rubber, etc. Lathes vary in price from $15 to $50 and upward. In fact, almost any amount of money may be invested in a foot lathe and the accessories which can be used in connection with it to great advantage.

The better way to proceed is to purchase a lathe complete, with fly-wheel, treadle, belt, chucks for turning wood, centers for turning metals, a face plate, one or two lathe dogs, a drill chuck, three or four hand tools for turning brass and other metals, and three or four tools for turning wood.

Not a great deal can be said in regard to the various kinds of work to be done on a foot lathe of this kind. More can be learned in a half hour by the observation of a skilled workman than can be acquired by a day's practice, or by a study of books. However, any one having a mechanical turn of mind can take the various

tools, and with the aid of a little common sense can soon master the art of hand turning.

After practice with the lathe the amateur soon finds that other tools are required, and he will either make them or buy them, and thus gradually add to his outfit until he is able to undertake any work that may come along.

To turn longer pieces of metal than can be held advantageously in the chuck, the pieces are centered, drilled, and then countersunk to fit the centers of the lathe, one of which is in the mandrel, the other in the tail-stock spindle. A lathe dog is placed on one end of the piece of metal and inserted in the slot in the face plate of the lathe, while the lathe center is inserted in the countersunk drill-hole in the end of the bar to be turned. The center carried by the tail-stock is brought forward and inserted. The tail-stock is then made fast to the lathe bed, and the center is adjusted by turning the tail-stock screw; the work should turn easily without chattering and the center should be oiled.

It is a good plan to finish the work without filing, but the file and emery paper may be used; they should be used with care, however, as they are liable to injure the angles and finer features of the work. A tool will give a fine finish on steel work if it is sharpened on a fine oil stone and the work is wet with oil or some other liquid; even saliva is often made use of with good effect. Brass and other materials softer than steel are readily turned in any form desired, and of course hard rubber and hard and soft woods are still more easily worked.

Turning brass, Babbitt metal, or type metal is not materially different from turning hard wood. The tools

are practically the same, and the methods are the same, but the metal turning is done at a somewhat slower speed. In the case of metals, the finishing of the sharpening of the turning tools is done on an oil stone to insure the smoothness of the work. The work should be so smoothly done that no final finishing will be required. If, however, brass work is to be finished it may be done by means of very fine emery paper or cloth. This may be applied by the hand or strips of it may be glued on flat or convex strips of wood which are used in the same manner as a file.

The amateur cannot expect to cut screw threads with chasers as readily as a skilled mechanic, but he can make some headway with practice on brass and hard wood. Chasers may be purchased for cutting inside and outside threads. The chaser is moved along the lathe rest at what is judged to be the speed the thread would carry it along if already cut in the brass or wood. The chaser is at the same time pressed firmly on the rest and brought into engagement with the material revolving in the lathe.

Make-shifts are not to be generally approved, but the writer will relate a circumstance which came to his knowledge some years ago that may be helpful to some one caught in a similar predicament.

A lathe was available but no screw-cutting tools of any kind were at hand. It was necessary to make one or two fittings for a half-inch gas pipe. Two old files were found and annealed, and in the end of one were filed with an ordinary triangular file the teeth to fit the threads of the gas pipe. In the side of the other file were filed teeth to fit the teeth of the first chaser. These teeth were filed at a slight inclination to cor-

respond roughly with the pitch of the screw thread. These chasers were hardened and tempered and used to good advantage in finishing work which would otherwise have been delayed at considerable inconvenience.

METAL-WORKING ON A LATHE

INSTRUCTIONS ABOUT DRILLS AND DRILLING

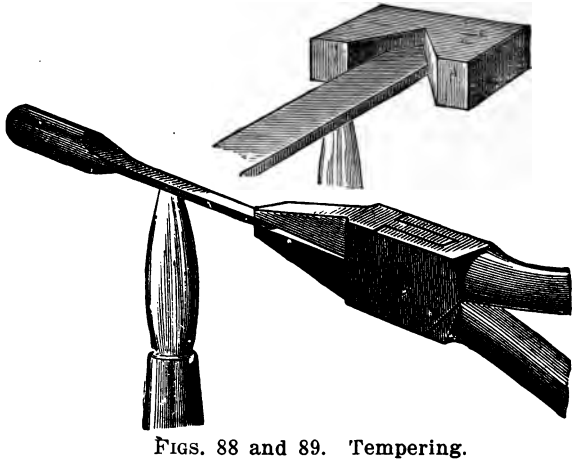
An ordinary flat drill for most purposes will answer nearly, if not quite, as well as a twist drill. It is not a difficult matter to make them, since we have such reliable material as Stubs' steel wire of every size. The best form of flat drill for general purposes is shown in Figs. 88, 89, and 90. It is made by milling or filing the opposite sides of the wire, so as to form a bit or blade having a thickness equal to about one-fourth of the diameter of the wire. The angle of the point should be 90 degrees, and the angle of its cutting edge about 45 degrees for most uses. For a drill for very hard substances these angles may be more obtuse.

Having formed the drill, it should be hardened by heating it to a low red and plunging it straight down into cool (not cold) water. In case of a very small drill, it may be held in the flame of a gas burner or lamp in a pair of spring nippers over a vessel of water. When it attains the required degree of heat it may be dropped into the water.

To temper for most cases, the drill, after being brightened on an emery wheel or piece of emery paper, is heated; if it is a small one, in an alcohol or gas flame, until its color at the point runs down to a brownish

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yellow verging on a purple. If the drill is very large it may be heated over a forge fire, or over a heavy piece of red-hot iron. If the drill is a very small one, it may be hardened and tempered at one operation by heating to a low red heat and plunging it immediately into a piece of beeswax.



FIGS. 88 and 89. Tempering.

If it is desired to have the point of the drill very hard, without being liable to breakage, its temper may be drawn by holding its point in pliers, as shown in Fig. 88, while the main portion is held over a gas flame. The cool jaws of the pliers prevent the point from becoming heated.

Another method, applicable to larger drills, is to employ a notched block of lead, as shown in Fig. 89. The drill in this case is driven a short distance into the lead before it is hardened; then, as it is tempered, it is replaced in the lead to preserve the hardness of the cutting edges while the temper is drawn in the other portions.

When a drill is hardened by immersing its point in mercury instead of water, it acquires a diamond-like hardness. The point of the drill just described is shown in perspective and in section at D in Fig. 90. The drill F is similar to the drill D, the point of difference being a half-round groove along each face adjacent to the cutting edge. This device gives the cutting edge a more acute angle, which is desirable for some kinds of work. G is a straight drill having concave or fluted sides, and E is the well known twist drill. The drills, G E, are shown in cross section in the central figure. Twist drills of recent manufacture have a central longitudinal line, which locates the point in grinding.

The best rule for grinding twist drills is to preserve as nearly as possible the original form. The ordinary pin drill, H, is used for counterboring, a hole being first drilled to receive the pin. The drill I is employed to give an ornamental appearance to plates in which pivots or small shafts are journaled, as in clock work. The bottoming drill, J, has three cutting edges, one upon each side, and a central transverse one connecting the other two. This drill, as its name indicates, is designed to make a flat bottom in a drill hole.

The pin drill, K, which is shown in side and end views in Fig. 93 is first carefully turned and afterward milled with the rose bit, L, producing the cutting points or lips, which are afterward beveled with a file. This drill is used for boring large holes in sheet metal, a small hole being drilled first to receive the pin. M is an expansion drill for the same purpose; its construction will be readily understood from the engraving. The spindle is mortised to receive the tool carrying

arm, which is secured in the mortise by a key. The lower end of the spindle is bored to receive the drill, which also forms the pin for guiding the cutter.

While universal chucks are recommended for holding drills, another form of chuck, shown in Fig. 91, may be used with equal advantage. It consists of a main

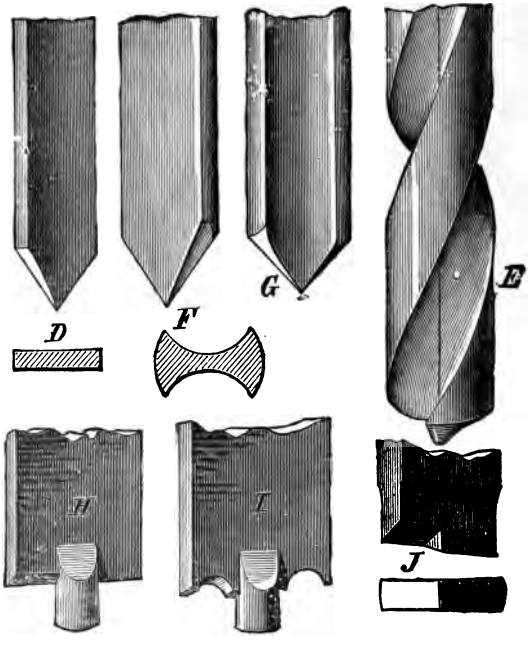


FIG. 90. Forms of Drills.

portion, A, which screws on the lathe spindle, and has a tapering threaded end for receiving the milled nut, B. The threaded end is split to admit of its contraction as the nut, B, is screwed on. The part, A, is bored longitudinally to receive sections, C, of iron or steel rod. To prepare this chuck for holding drills, the pieces, C,

are inserted in the chuck, centered with a pointed tool, and are drilled with the drill with which they are intended to be used. They are then split longitudinally with a saw for about three-fourths their length. The pieces, C, when once prepared, will always answer for the same sized drill; they may also be used with an ordinary chuck having a set screw.

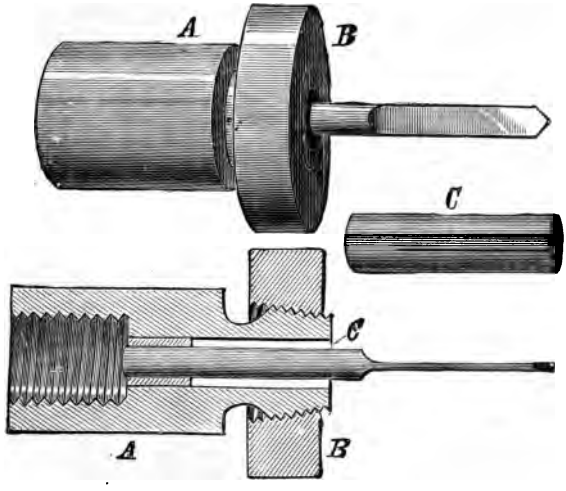


FIG. 91. Drill Chuck.

The fluted countersink, O, may be classed among the drills; its special application is to form the centers of articles to be turned. It has the same form as the lathe centers, and makes a truly circular conical hole, providing the number of flukes or cutting edges is odd.

Every lathe should be provided with a plate, or drill rest, P, fitted to the tail spindle, for supporting plain work while drilling it. The lathe should also have a

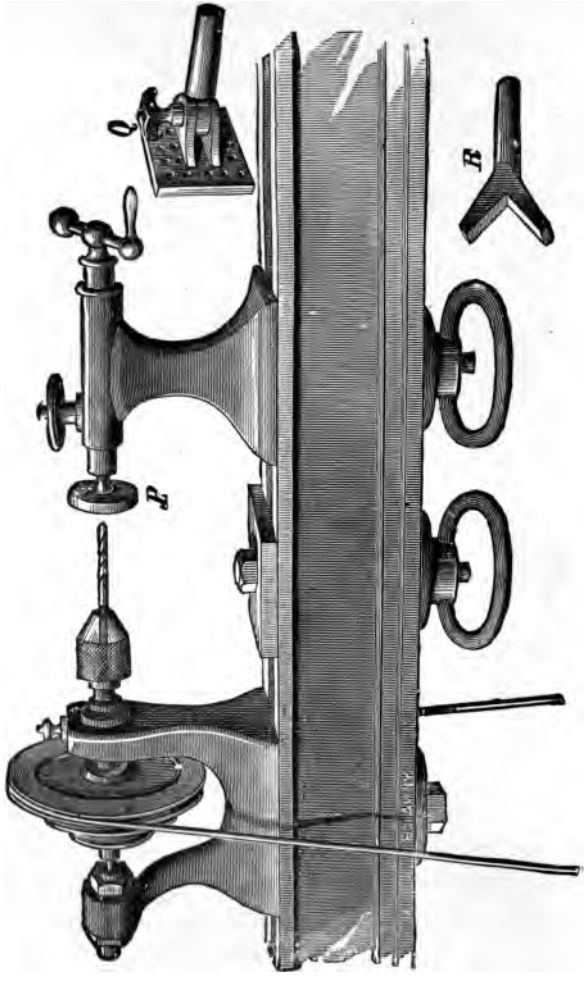


FIG. 92. Lathe, with Work Support.

hinged or pivoted rest, Q, which may be clamped at any desired angle for drilling irregular work. This plate should have several perforations for receiving pins, for preventing the work from slipping. For supporting cylindrical objects to be drilled transversely, a fork, R, is inserted in the tail spindle.

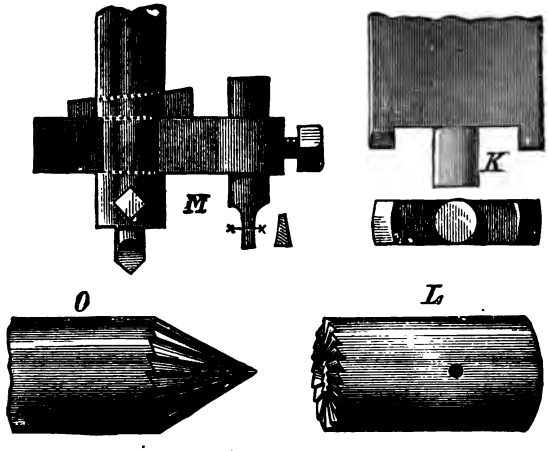


FIG. 93. Drills and a Rose Bit.

As to the matter of drilling, little need be said, as nearly everything must be learned by experience; however, a few points may be mentioned. The work should be carried forward with a regular and not too heavy pressure. The speed of the drill will vary with the material being worked. For steel, wrought iron, and copper, the speed should be slow; for brass and cast iron, it may be quite rapid. In drilling steel or wrought iron, oil is the best lubricant for the drills; in drilling glass, the drill should be wet with turpentine.

HINTS CONCERNING CENTERING AND STEADYING

To center a cylindrical piece of metal readily and accurately is a very simple matter when the workman is provided with tools especially designed for the purpose, and it is not difficult when an engine lathe or even an engine rest is available; but to do it easily and properly in an ordinary plain foot lathe may puzzle some of

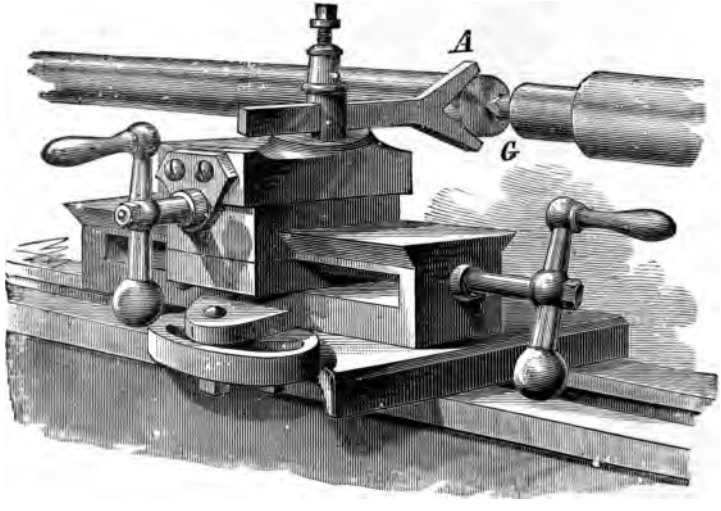


FIG. 94. Centering with a Forked Tool.

the amateur mechanicians. Although some of these methods are well known, they will nevertheless be described for the benefit of some who may require the information. The method of centering shown in Fig. 94 is one of the most common where the lathe is provided with an engine rest. A forked tool, A, is clamped in the tool post in such a position that a line drawn from the point of the tail center will bisect the

angle of the fork. A square pointed center, G, is inserted in the tail spindle and moved against the end of the rod being centered with

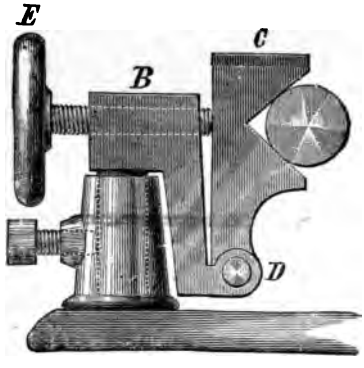


FIG. 95. Centering.

a slight pressure, the tool, A, being at the same time moved forward by the screw of the engine rest until the rod turns smoothly in the fork and the square

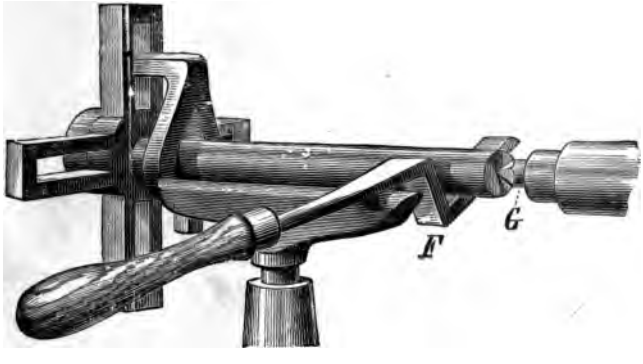


FIG. 96. Centering with a Hand Tool.

pointed center has found the center of the rod; the tail spindle is then moved forward until the cavity is sufficiently deep to permit of starting the center drill. The

angle of square center, G, for very hard material, should be a little more obtuse than that shown in Fig. 97. In any case, it should be of good material and well tempered.

In Fig. 95 is shown a centering tool which is designed to take the place of the engine rest and fork in Fig. 94. The part B is fitted in place of the ordinary tool rest,



FIG. 97.

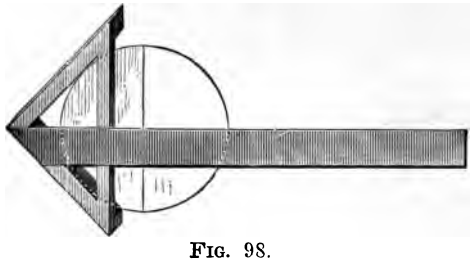


FIG. 98.

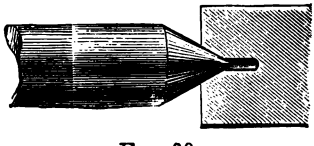


FIG. 99.



FIG. 100.

and the jaw, C, which has in it a V-shaped notch, is hinged to the part B at D. A screw, E, passes through the upper end of the part B, and bears against the jaw, C. After what has already been said in connection with the engine rest, the manner of using this contrivance will be readily understood.

In Fig. 96 the hand tool, F, is employed for steadying

the shaft and bringing it to a center. This tool is bent to form a right-angled notch for receiving the shaft, and when in use it is supported by the tool rest after the manner of an ordinary hand turning tool.

Work that is too large to be readily centered in this manner is often centered approximately by means of the universal square, as shown in Fig. 98. A diamet-

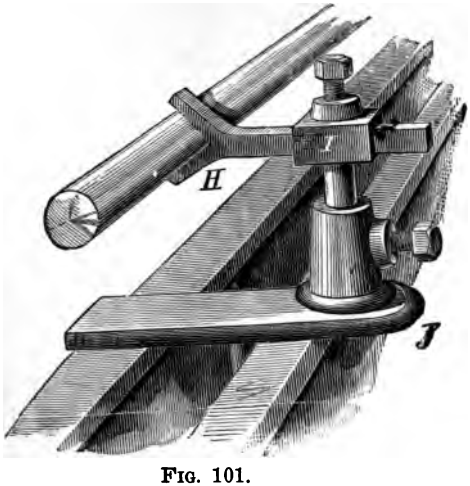


FIG. 101.

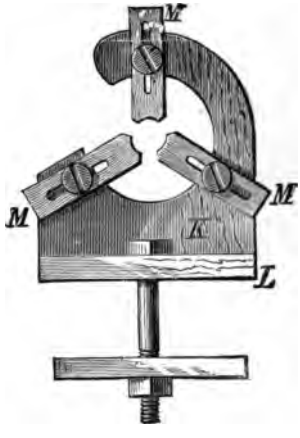


FIG. 102.

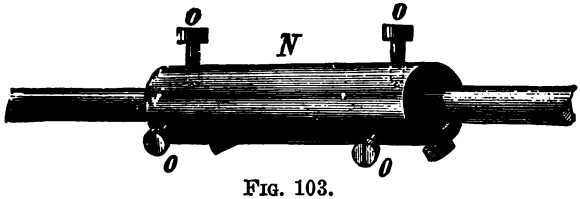


FIG. 103.

Steadying Devices.

rical line is drawn along the tongue of the square, the work is then turned through a quarter of a revolution, and another line is drawn. The intersection of these lines will be the center, at least approximately.

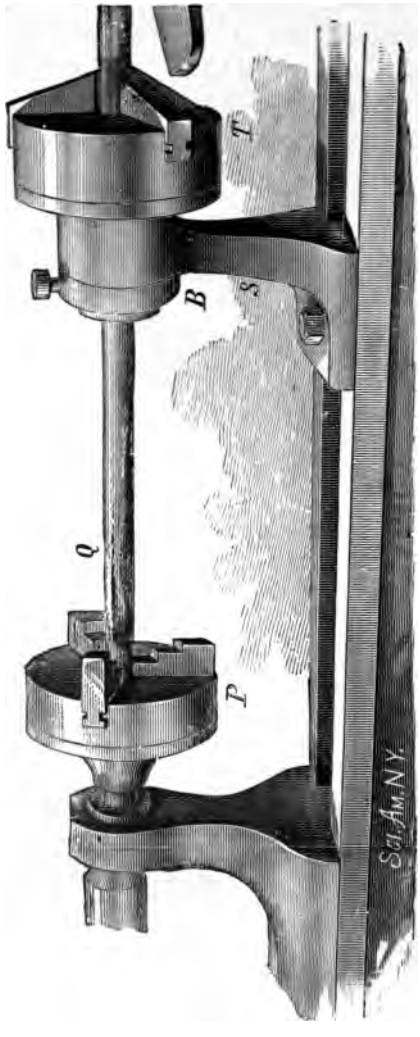


Fig. 104. Turning Long Rods.

This point may now be marked with a center punch, and the work may be tested in a lathe. If it is found to revolve truly on the centers it may be drilled, otherwise the center must be corrected with the center punch, and the work again tested in the lathe.

After centering by any of these methods, the center must be drilled and countersunk with a suitable tool, so that it will fit the lathe center, as shown in Fig. 99. The angle of the lathe centers should be sixty degrees. To insure uniformity in everything pertaining to the centers, the center gauge, shown in Fig. 100, should be used for getting the required angle on the lathe centers and on the drills used in centering.

The matter of steadying the long, slender rods while being turned in the lathe is often perplexing.

In some cases it may be done tolerably well in the manner illustrated in Fig. 101. The fork, H, is supported by the standard, I, which is inserted in the socket of the rest support, J. The device shown in Fig. 95 may be used in a similar way.

Fig. 102 represents a steady rest, the construction of which will hardly need explanation. For light work it may be made of wood; the upright being secured to the cross piece, L, which rests upon the lathe bed. The slotted pieces, M, are adjustable lengthwise to accommodate the size and position of the shaft. When it is required to support a bar which is not round, the sleeve, N, shown in Fig. 103, is employed. It slips over the shaft and revolves in the steady rest. The bar is centered by the screws, O.

The device shown in Fig. 104 is used where a hollow mandrel lathe is not at hand. A piece of gas pipe, Q, is held by the chuck, P, and is secured by a set screw in

the sleeve, B, which is journaled in the standard, S, and carries the chuck, T. This arrangement may also be employed for turning the ends of long rods where it is not desirable to put them regularly on the centers of the lathe.

CHUCKING

In spite of all possible appliances to be used in a general way for chucking work in the lathe, a degree of inventive skill is often required to accomplish it quickly

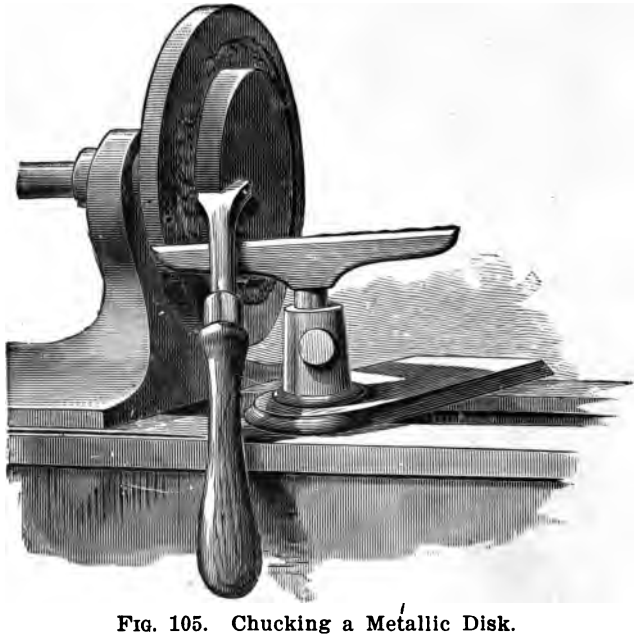


FIG. 105. Chucking a Metallic Disk.

and securely. The accompanying cuts are designed to aid the amateur in chucking, but after all is said, there is a world of knowledge that can be gained by experience only.

The arrangement of a metal disk in the lathe so that it can be turned on its face, and upon its edge, cannot well be accomplished by means of chucks; for this purpose recourse is frequently had to cement. A good

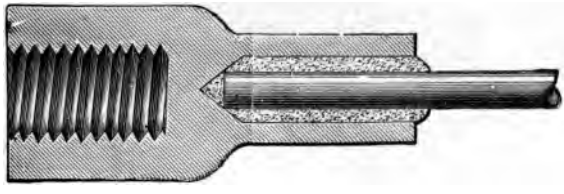


FIG. 106. Chucking a Spindle.

cement for this purpose consists of Burgundy pitch, 2 pounds; resin, 2 pounds; yellow wax, 2 ounces; dried whiting, 2 pounds; melt together the pitch, resin, and wax, and stir in the whiting.

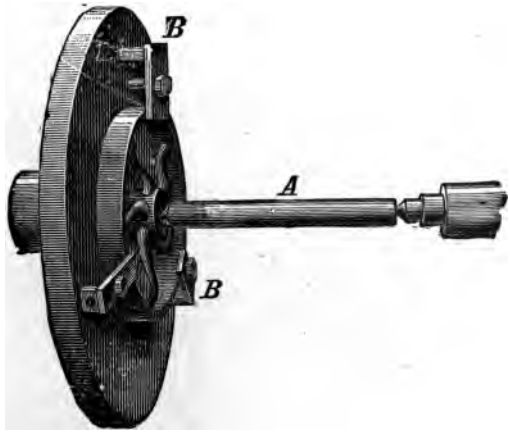


FIG. 107. Chucking Work on Face Plate.

To chuck work with this cement, apply a small portion of it to a face plate devoted especially to this purpose; heat the plate so that the cement will cover the

greater portion of its surface. The plate may be allowed to cool. Whenever it is desirable to chuck a metallic disk, it is heated and placed against the cement on the face plate, and allowed to remain until the cement begins to stiffen, when a tool having a right-angled notch is applied to the edge of the disk, as shown in the cut, the lathe being rotated until, by the compound action of the tool pressure and the rotary motion, the disk becomes perfectly true.

To chuck a spindle or any similar object a cement chuck like that shown in section in Fig. 106 is sometimes used. The larger portion is screwed on the lathe mandrel, and the inner end of the hole in the outer portion terminates conically. The hole is filled with cement, and the article to be chucked is warmed and introduced. It may sometimes be necessary to heat the chuck with an alcohol or gas flame. The lathe is rotated, and the spindle is held lightly until it becomes true and the cement begins to harden.

To remove the work from a cement chuck, it must be warmed by means of a lamp or otherwise. Most of the cement adhering to the work may be wiped off after heating it; whatever remains may be removed with a little turpentine.

A common method of chucking work on the face plate is shown in Fig. 107; the wheel is temporarily retained in place by a pointed rod, A, which is forced against the wheel by the tail spindle. A little rapping one way or the other readily centers the wheel. A piece of crayon held in a crayon holder supported by the tool rest may be used to discover which side of the wheel is "out." After the wheel is trued, it is fastened by the short bars, B, whose outer ends rest upon any convenient blocking

while they are drawn by the bolts, so as to clamp the wheel firmly to the face plate.

It is sometimes preferable to use the yoke shown in Fig. 108 instead of the bars shown in Fig. 107; it is placed diametrically across the wheel and secured by two bolts.



FIG. 108. Yoke.

Fig. 109 represents a chuck consisting of a wooden disk, *c*, bored to receive the wooden hoop, *d*, which may be forced inward by the common wood screws, *e*, which bear upon it. This chuck is useful where a considerable number of similar pieces are to be turned or bored.

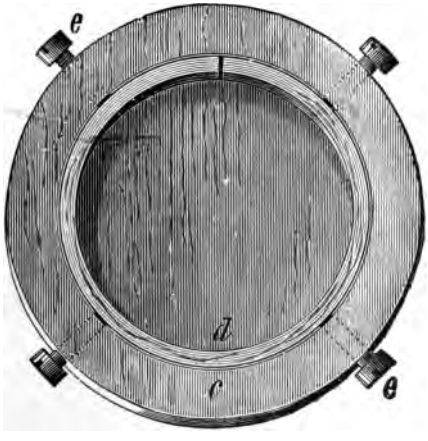


FIG. 109. Wood Chuck for Duplicate Work.

Fig. 110 represents a simple and well known chuck. It is simply a block of wood secured to a face plate by a screw center and turned out to fit the work.

Fig. 111 represents an easily made chuck, which is useful for holding plugs of wood to be turned or bored. It consists of a piece of hard wood fitted to the mandrel, turned, bored, and split longitudinally, as shown in the

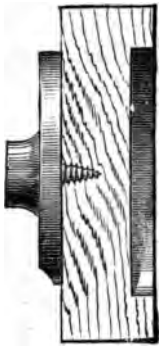


FIG. 111.

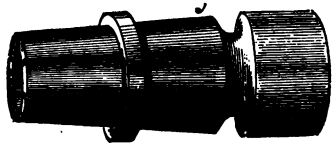


FIG. 110.

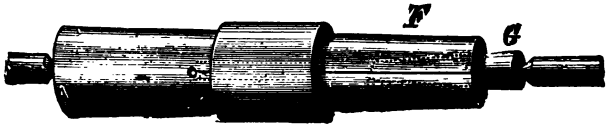


FIG. 112.

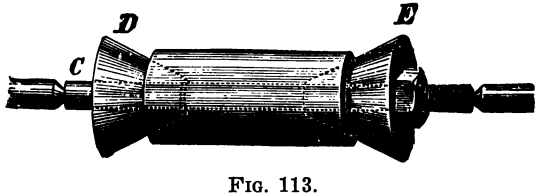


FIG. 113.

Chucking Devices.

engraving. Its outer end is tapered, and to it is fitted a metallic ring that serves to contract the chuck when it is forced on.

Fig. 112 represents a tapered and split mandrel,

which may be either of metal or wood according to the purpose to which it is to be applied. The part F is bored conically at the smaller end before splitting, and to this hole is fitted the conical plug, G, which being forced in expands the mandrel.

In Fig. 113 the mandrel, C, has permanently attached to it the cone, D, and upon it is placed the movable

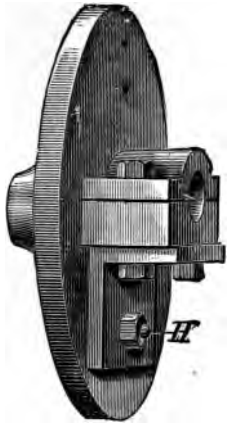


FIG. 114.
Chucking on Angle Plate.

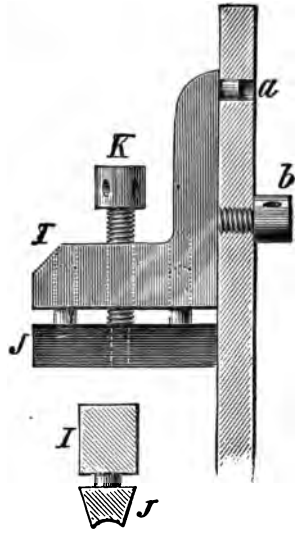


FIG. 115.
Face Plate Jaw.

cone, E, which is forced against the work held between the two cones by a nut which turns on the threaded end of the mandrel.

In Fig. 114 the manner of chucking work on the angle plate, H, is shown so clearly as to require no explanation. It may be well, however, to state that when the work is rotated rapidly a counterbalance

should be attached to the face plate on the side diametrically opposite the angle plate.

Fig. 115 shows a jaw for attachment to the face plate, which consists of a right-angled piece, I, a jaw, J, which has two guide pins, entering holes in the piece, I, and the screw, K, which passes through a tapped hole in the piece, I, and bears against the jaw, J. The piece, I, has a dowel, *a*, that keeps it from turning, and a screw, *b*, by which it is secured to the face plate.

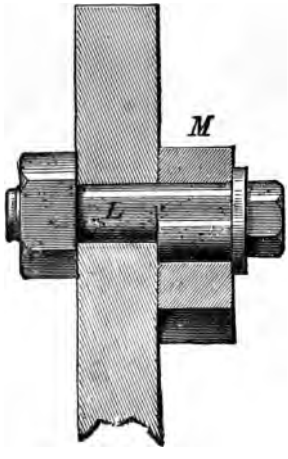


FIG. 116.



FIG. 117.

In Figs. 116 and 117 the pin, L, is fitted to the face plate, and has formed on its projecting end an eccentric which fits the jaw, M. It has also a hexagonal head for receiving the wrench by which it is turned. Three pins, L, are fitted to the face plate, which is quite thick. Two of the pins need not be turned after being adjusted for a certain kind of work; the third is loosened and turned when work is put in and taken out of the lathe.

After the work is clamped tightly by turning the eccentric the nut on the back of the face plate is tightened.

In Fig. 118 is shown a type of the most convenient and most universally useful chuck in existence. Its



FIG. 118. Scroll Chuck.

construction and use are so well known as to need no description. The jaws are simultaneously moved to or from the piece of metal which is being machined by the aid of a key. Such chucks hold drills admirably.

METAL TURNING

In selecting a lathe an amateur may exercise more or less taste, and he may be governed somewhat by the length of his purse; the same is true in the matter of chucks; but when he comes to the selection or making of turning tools he must conform to fundamental principles; he must profit as far as possible by the experience of others, and will, after all, find enough to be learned by practice.

Tools of almost every description may be purchased at reasonable prices, but the practice of making one's

own tools cannot be too strongly recommended. It affords a way out of many an emergency, and where time is not too valuable, a saving will be realized. A few bars of fine tool steel, a hammer, and a small anvil, are all that are required, aside from fire and water. The steel should be heated to a low red, and shaped with as little hammering as possible; it may then be allowed to cool slowly, when it may be filed or ground to

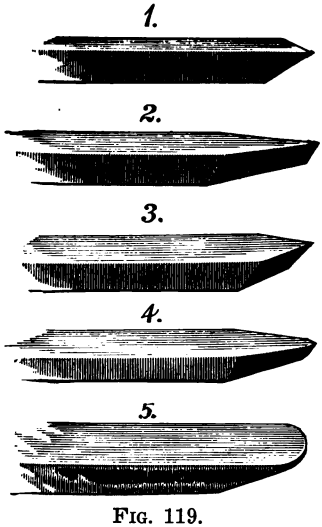


FIG. 119.

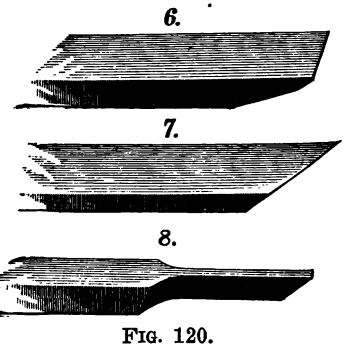


FIG. 120.

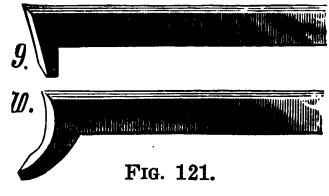


FIG. 121.

Metal Lathe Tools.

give it the required form. It may now be hardened by heating it to a cherry red and plunging it straight down into clean cool (not too cold) water. It should then be polished on two of its sides, when the temper may be drawn in the flame of an alcohol lamp or Bunsen gas burner; or, if these are not convenient, a heated bar of iron may be used instead, the tool being placed in con-

tact with it until the required color appears. This for tools to be used in turning steel, iron, and brass may be a straw color. For turning wood it may be softer. The main point to be observed in tempering a tool is to have it as hard as possible without danger of its being broken while in use. By a little experiment the amateur will be able to suit the temper of his tools to the work in hand.

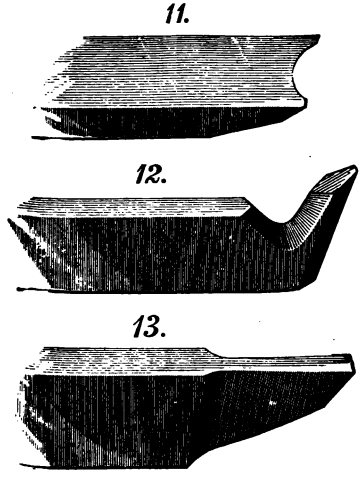


FIG. 122.

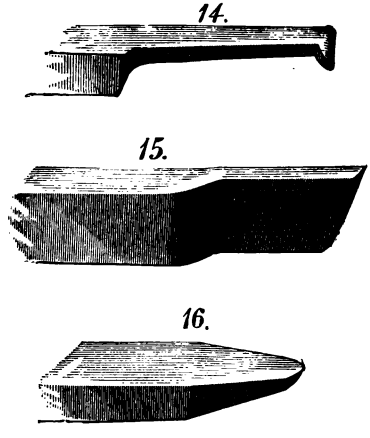


FIG. 123.

Metal Lathe Tools.

In the engravings accompanying the present section a number of hand turning tools are shown, also a few tools for the slide rest. These tools are familiar to machinists and may be well known to many amateurs; but we give them for the benefit of those who are unacquainted with them and for the sake of completeness in this volume.

No. 1, Fig. 119, is the ordinary diamond tool, made from a square bar of steel ground diagonally so as to give it two similar cutting edges. This tool is perhaps more generally useful than any of the others. The manner of using it is

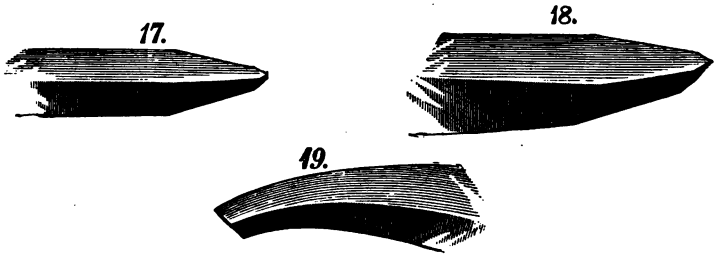


FIG. 124. Metal Lathe Tools.

shown in Fig. 127; it is placed on the tool rest and dexterously moved on the rest as a pivot, causing the point to travel in a circular path along the metal in the lathe. Of course only a small distance is traveled over before the tool is moved along on the



FIG. 125. Drill and Holder.

rest. After a little experience it will be found that by exercising care a good job in plain turning may be done with the tool.

No. 2, Fig. 120, shows a sharp V-shaped tool which will be found useful for many purposes. No. 3 is a V-shaped tool for finishing screw threads. Nos. 4 and

5 are round-nosed tools for concave surfaces. No. 6 a square tool for turning convex and plane surfaces. The tool shown in No. 7 should be made right and left; it is useful in turning brass, ivory, hard wood, etc. No. 8 is a separating tool. No. 9 is an inside tool, which should be made both right and left, and its point may be either round, V shaped or square.

Fig. 128 shows the manner of holding an inside tool. No. 10 is a tool for making curved undercuts. No. 11

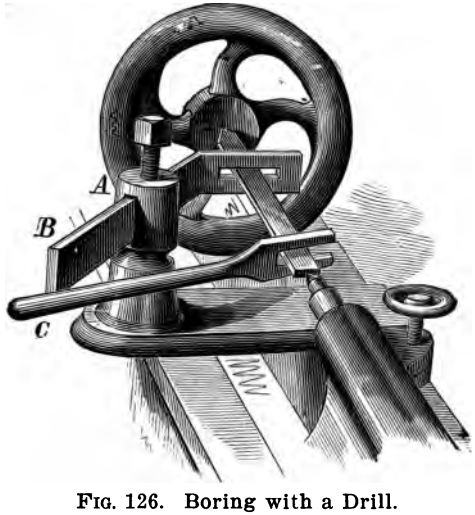


FIG. 126. Boring with a Drill.

is a representative of a large class of tools for duplicating a given form.

These figures represent a series of tools which may be varied infinitely to adapt them to different purposes. The user, if he is wide awake, is not long in discovering what angle to give the cutting edge, what shape to give the point, and what position to give the tool in relation to the work to be done.

Having had experience with hand tools it requires only a little practice and observation to apply the same principles to slide rest tools.

A few examples of this class of tools are given. No. 12 is the ordinary diamond pointed tool, which should be made right and left. The cutting edge may have a more or less acute angle, according to the work to be



FIG. 127. Using the Diamond Tool.

done, and the inclined or front end of the tool may be slightly squared or rounded, according to the work. Fig. 13 is a separating tool, which is a little wider at the cutting edge than anywhere else, so that it will clear itself as it is forced into the work.

For brass this tool should be beveled downward slightly. By giving the point the form shown in No. 3 it will be adapted to screw cutting.

No. 14 shows an inside tool for the slide rest; its point may be modified according to the work to be done. No. 15 is a side tool for squaring the ends of shafts; Nos. 16, 17, 18 and 19 represent tools for brass; No. 16 is a round-nosed tool for brass, No. 17 a V-shaped tool, No. 18 a screw thread tool, and No. 19 a side tool. In boring, whether the object is cored or not, it is desirable, where the hole is not too large, to take out the first cut with a drill. The drill and the drill holder



FIG. 128. Method of Holding an Inside Tool.

for the purpose is shown in Fig. 125, and the manner of using in Fig. 126. The drill holder, B, is held by a mortised post placed in the rest support. The slot of the drill holder is placed exactly opposite the tail center and made secure. The drill, which is flat, is drilled to receive the tail center, and it is kept from turning by the holder, and is kept from lateral movement and chattering by a wrench, C, which is turned so as to bind the drill in the slot of the holder.

The relative position of the tool and work is shown

in Fig. 129. The upper cut shows the position for brass; the next for iron and steel; the third, the relative position of the engine rest tool and its work, and the fourth the position of the tool for soft metal and wood.

In all of these cases the point of the tool is above

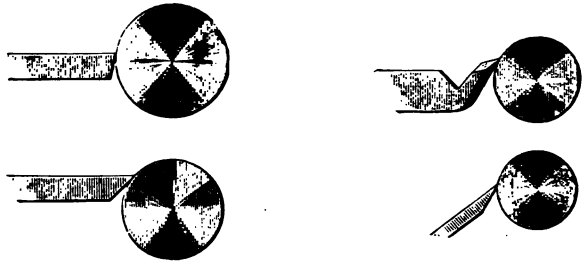


FIG. 129. Position of Cutting Tools.

the center of the work. In the matter of the adjustment of the tool, as well as in all other operations referred to, experiment is recommended as the best means of gaining valuable knowledge in the matter of turning metals.

CHASING AND KNURLING

Among the multitude of operations possible with a foot lathe perhaps none is more vexatious to the amateur than that of cutting a good screw thread, and no acquirement is more valuable than to be able to chase a screw thread easily and accurately.

The ordinary chaser, No. 1, Fig. 130, is a simple tool which is easily made when one has the hubs for the different sizes; but wanting these, we recommend the purchase of chasers. A blank for an outside chaser is shown in No. 2, and the hub used in cutting the teeth is represented in Fig. 131. The latter consists

of a piece of good steel having a thread of the desired pitch, which is traversed by spiral grooves to form cutting edges. This tool must have about the same temper as that of a tap. When used it is placed between the lathe centers and revolved at a slow speed,

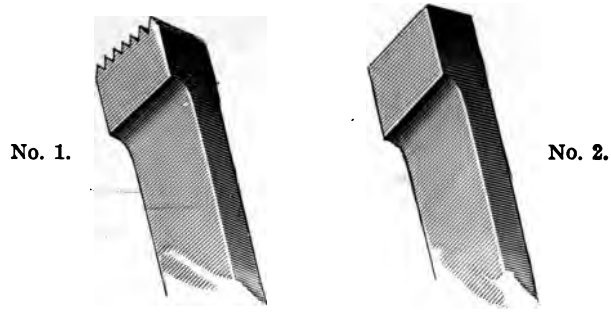


FIG. 130. Chaser and Blank.

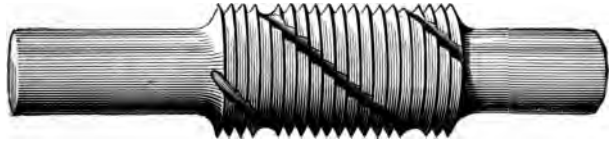


FIG. 131. Hub.



FIG. 132. Inside Chaser.

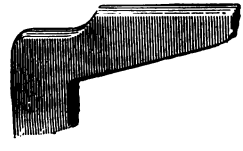


FIG. 133. Blank for Chaser.

while the end of the chaser blank is held against it, being at the same time supported by the tool rest. The hub should be oiled during the cutting process. After cutting, the tool is hardened and tempered, and ground on the elevated portion, which is the face, and smoothed on the back which slides upon the tool rest.

An inside chaser is shown in Fig. 132, the blank from which it is made in Fig. 133. For convenience in cutting the teeth, the blank is bent at right angles; after cutting and before hardening it is straightened.



FIG. 134. Starting a Thread.

The manner of starting a thread for chasing is shown in Fig. 134, the tool used being shown. The rest is placed a short distance from the work, the tool is held

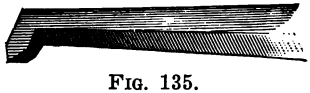


FIG. 135.

firmly upon it, and while the work revolves with a uniform speed the tool is moved dexterously so as to make a spiral line on the work, which is nearly, if not exactly, of the same pitch as the thread to be cut.

If the operator is fortunate in the attempt, it will be a simple matter to start the chaser and move it along as indicated in Fig. 136. After a little practice it will in most cases be found an easy matter to chase threads without first starting them with a pointed tool. It is much easier to chase an inside thread than an outside one. A chaser seldom goes wrong when working on the inside.



FIG. 136. Chasing a Thread.

A method of chasing thimbles is shown in Fig. 137. The threaded thimble which forms the guide screw is driven on the larger end of the tapering mandrel; the thimble on which the thread is to be cut is placed on the smaller end of the mandrel. One arm of the forked tool has a vertical chisel edge, which engages the guide screw; the other arm has a chasing point which cuts

the thread. The chisel edge is first brought into engagement with the guide screw, the point is then quickly brought against the work with more or less pressure. After the thread is well started it may be finished with an ordinary chaser or with a pointed tool.

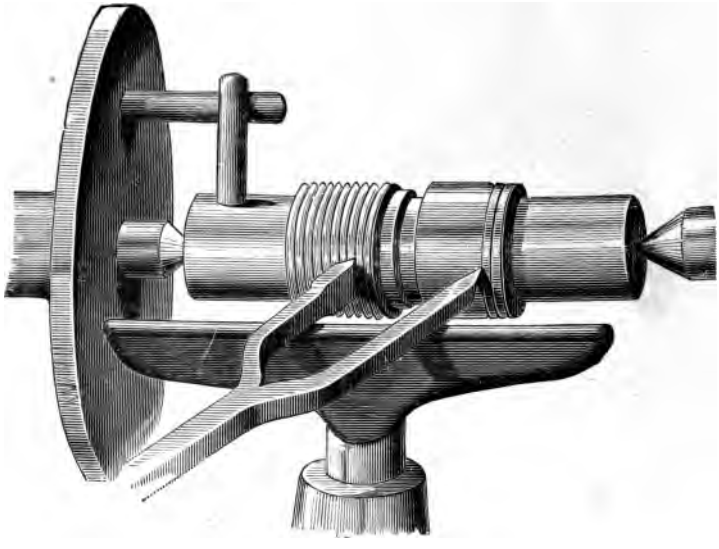


FIG. 137. Chasing Thimbles.

Fig. 138 shows a method of starting an inside thread. The chaser has a tracing edge that follows the guide screw projecting from the center of the chuck, and a cutting point that forms the thread. Fig. 139 shows the tool in detail.

Threads cut by a chaser without some kind of a guide to start them are often more or less crooked or drunken. To correct such threads and in cutting large threads, the doctor, shown in Fig. 140, is sometimes

employed. The follower opposite the chaser is moved up by the thumbscrew as the thread deepens.

The most expensive, and at the same time the most desirable, contrivance for chasing screw threads is shown in Fig. 141. A casting fitted to the lathe bed has two ears, which are bored to receive the round

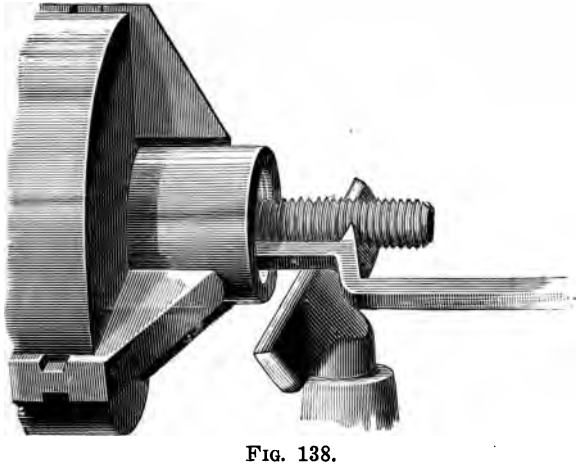


FIG. 138.

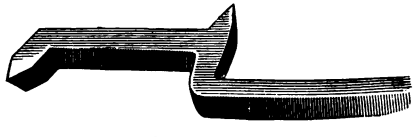


Fig. 139. Chasing Inside Threads.

sliding rod carrying the tool holder and tracer. The tool holder is placed on the sliding rod between the two ears, and it carries a well-fitted screw, which bears against the horizontal bar supported by two square posts, which form a part of the main casting. This bar forms a guide which may be adjusted within narrow limits by the screw seen in the right hand post.

The lathe is provided with a face plate having a long boss arranged to receive thimbles having leading threads of different pitches cut on them. The tracing arm carries a thin tracing which engages the threaded thimbles, and is capable of yielding to admit of moving the cutting tool forward against the object being threaded; but being well fitted to the mortise in the arm it cannot move laterally without carrying the sliding rod and all attached to it. The tracing tool is slotted to receive a pin which passes transversely

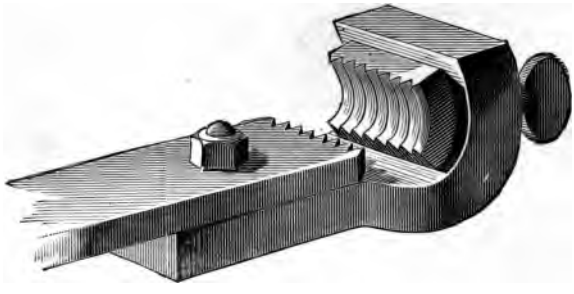


FIG. 140. A Doctor for Cutting Large Threads.

through the head of the tracing arm, and in the slot is placed a spiral spring which tends to throw the tracer forward.

The operation of this device needs no special explanation. The arm that carries the cutting tool is moved forward until its adjusting screw strikes the horizontal guide bar; the tracing tool at the same time engages the leading screw and carries all forward. When the tool has traveled as far as desirable it is drawn back and returned to its original position. With this tool threads may be cut on either cylindrical or tapering work.

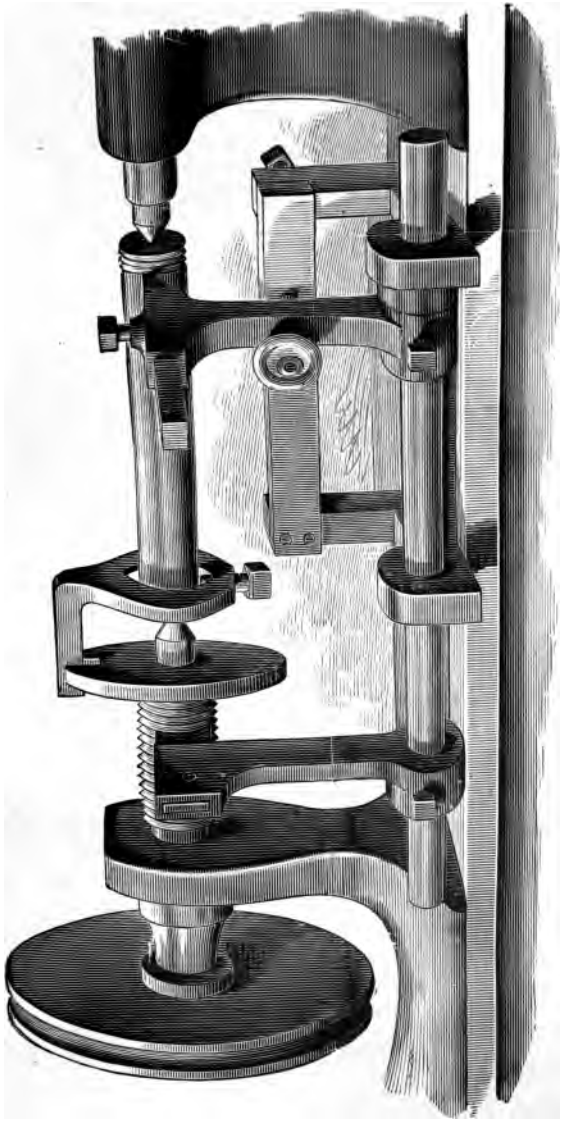


FIG. 141. A Good Method for Cutting Threads.

It is sometimes desirable to form spiral grooves in the face of a disk; this may be accomplished in exactly the same manner as in the case of the cylindrical work. The method of doing it is illustrated by Fig. 142.

Knurls of various patterns are shown in Fig. 143. These are employed in "beading," "milling," or knurling the heads of screws, the handles of small tools, etc. The manner of using this tool is shown in Fig. 145.

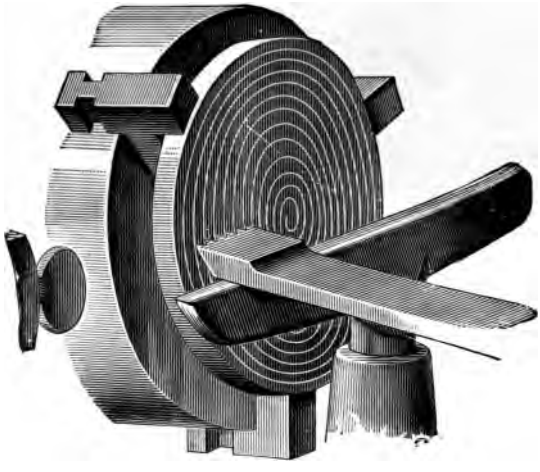


FIG. 142. Cutting Spiral Grooves.

The knurl is placed between the forks of a holder and upon a pin that passes through the fork, and is held with considerable pressure against the work as it revolves.

The knurls shown in Fig. 144 are easily made. All that is required is a hub something like that shown in Fig. 131. This is placed between the centers of the lathe, and the knurl blank is brought in contact with it and allowed to revolve in a holder supported

by the tool rest. The straight blank is moved up and down until every part of the surface is cut in the same way. The concave blanks cannot be moved, but the



FIG. 143. Knurls.

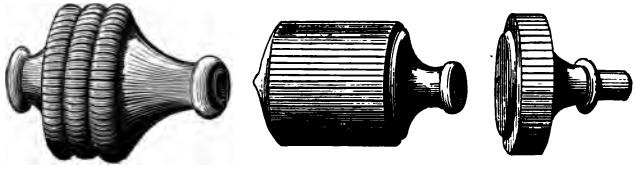


FIG. 144. Examples of Knurling.

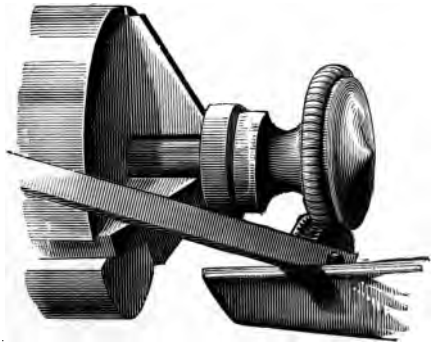


FIG. 145. Knurling.

hub should fit the hollow of the face of the blank. The fancy knurl shown in Fig. 143 must be made by a die sinker. Fig. 144 represents examples of knurling done with knurls shown in the preceding figure.

ROTARY CUTTERS

The saving of files, time, materials and patience, by the employment of such rotary cutters as may be profitably used in connection with a foot lathe, can hardly be appreciated by one who has never attempted to use this class of tools. It is astonishing how much very hard labor may be saved by means of a small

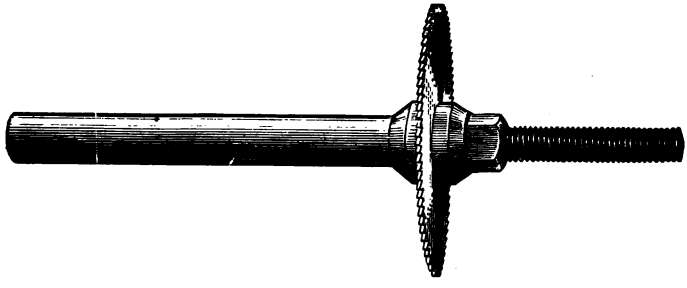


FIG. 146. Metal Circular Saw.

circular saw like that shown in Fig. 146. This tool, like many of the others described in this section, can, in most instances, be purchased cheaper than it can be made, and the chances are in favor of its being a more perfect article. However, it is not so difficult to make as one might suppose. A piece of sheet steel may be chucked upon the face plate, or on a wooden block attached to the face plate, where it may be bored to fit the saw mandrel, and cut in circular form by means of a suitable hand tool. It may then be placed upon the mandrel and turned true, and it is well enough to make it a little thinner in the middle than at the periphery.

There are several methods of forming the teeth on a circular saw. It may be spaced and filed, or it may

be knurled, as shown in Fig. 147, and then filed, leaving every third or fourth tooth formed by the knurl; or it may, for some purposes, be knurled and not filed

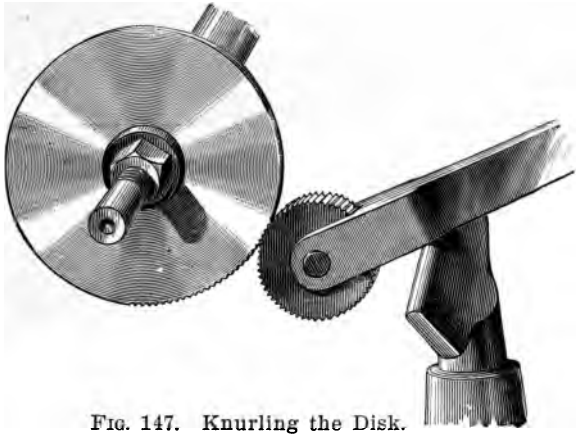


Fig. 147. Knurling the Disk.

at all. Another way of forming the teeth is to employ a hub, something like that used in making chasers, as shown in Fig. 148. The difference between this hub and the other one referred to, is that the thread has one straight side corresponding with the radial side of

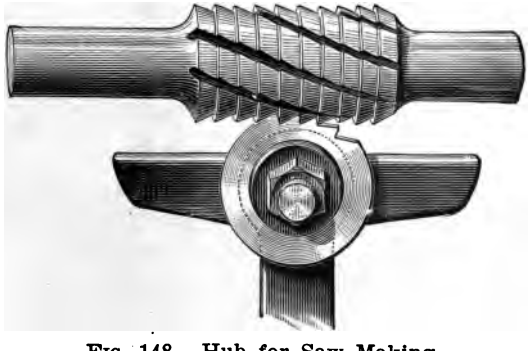


Fig. 148. Hub for Saw Making.

the tooth. The blank from which the saw is made is placed on a stud projecting from a handle made specially for the purpose, and having a rounded end which supports the edge of the blank, as the teeth are formed by the cutters on the hub.



FIG. 149. Small Saw.

The saw, after the teeth are formed, may be hardened and tempered by heating it slowly until it attains a cherry red, and plunging it straight down edgewise into cool, clean water. On removing it from the water it should be dried and cleaned with a piece of emery paper, and its temper drawn to a purple over a Bunsen gas flame, over the flame of an alcohol lamp or over a hot plate of iron. The small saw shown in Fig. 149 is easily made from a rod of fine steel. It is very useful for slitting sheet brass and tubes, slotting small shafts, nicking screws, etc. Being quite small it has



FIG. 150. Mandrel.



FIG. 151. Cutter.

the advantage of having few teeth to keep in order, and it may be made harder than those of larger diameter. A series of them, varying in diameter from one-eighth to three-eighths of an inch, and varying considerably in thickness, will be found very convenient.

These cutters or saws, with the exception of the smaller one, may be used to the best advantage in connection with a saw table, like that shown in Fig. 153. This is a plane iron table having a longitudinal groove in its face to receive the guiding rib of the carriage, shown in Fig. 154, and a transverse groove running half way across, to receive a slitting gauge, as shown in Fig. 153. The table is supported by a standard or shank, which fits into the tool-rest socket. The saw

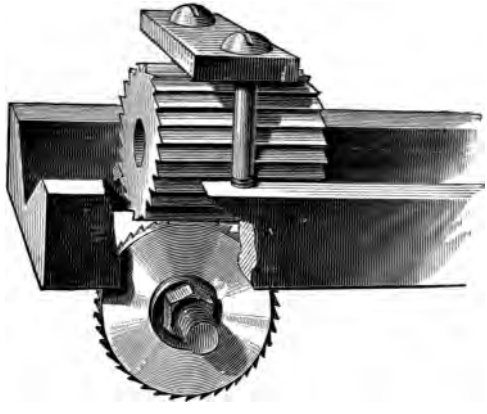


FIG. 152. Making a Cutter.

mandrel is supported between the centers of the lathe, and the saw projects more or less through a slot formed in the table. The gauge serves to guide the work to be slotted, and other kinds of work may be placed on or against the carriage, shown in Fig. 154.

It is a very simple matter to arrange guiding pieces for cutting at any angle, and the saw table may be used for either metal or wood. The saws for wood differ from those used for metal; the latter are filed straight, the former diagonally or fleaming. Among

the many uses to which metal saws may be applied we mention the slitting of sheet metals, splitting wires and rods, slotting and grooving, nicking screws, etc. Fig. 155 shows a holder for receiving screws to be nicked. It is used in connection with the saw table, and is moved over the saw against the gauge.

To facilitate the removal of the screws the holder may be split longitudinally and hinged together. Another method of nicking screws is illustrated by Fig.

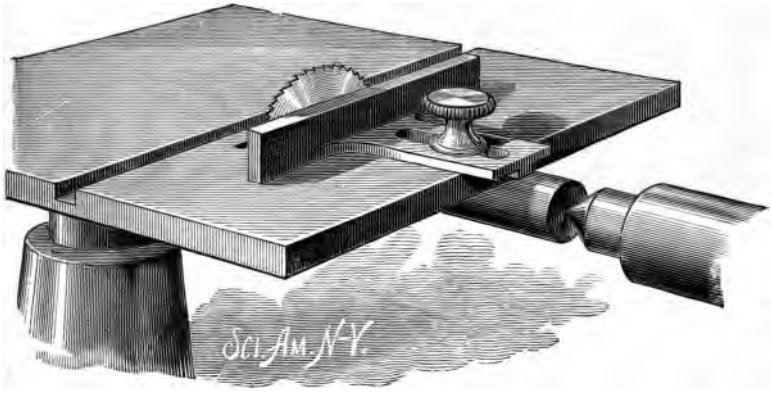


FIG. 153. Saw Table.

156. A simple lever, fulcrumed on a bar held by the tool post, is drilled and tapped in the end to receive the screw. After adjusting the tool all that is required is to insert the screw and press down the handle so as to bring the screw head into contact with the saw.

Where a lathe is provided with an engine rest, the cutter shown in Fig. 151, mounted on the mandrel shown in Fig. 150, is very useful; it is used by clamping the work to the slide rest and moving it under the cutter by working the slide rest screw.

To make a cutter of this kind is more difficult than to make a saw, and to do it readily a milling machine would be required. It may be done, however, on a plain foot lathe, by employing a V-shaped cutter and

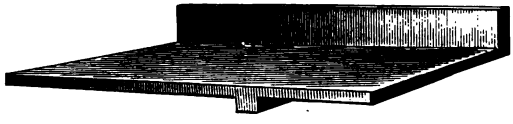


FIG. 154. Saw Carriage.

using a holder (Fig. 152) having an angular groove for receiving the cylinder on which the cutting edges are formed. The blank can be spaced with sufficient accuracy, by means of a fine pair of dividers, and after the first groove is cut there will be no difficulty in getting the rest sufficiently accurate, as a nib inserted in the side of the guide enters the first groove and all of the others in succession and regulates the spacing.

One of the best applications of this tool is shown in the small engraving. In this case a table similar to the saw table before described is supported in a vertical position, and arranged at right angles with



FIG. 155. Holder for Screws.

the cutter mandrel. The mandrel is of the same diameter as the cutter, and serves as a guide to the pattern which carries the work to be operated upon. The principal use of this contrivance is to shape the edges of

curved or irregular metal work. The casting to be finished is fastened—by cement if small, and by clamps, if large—to a pattern having exactly the shape required in the finished work.

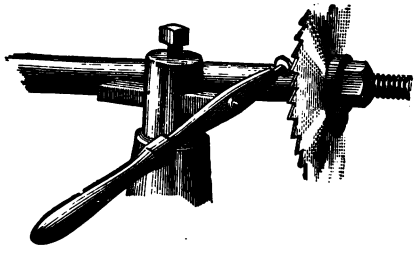


FIG. 156. Nicking Screws.

By moving the pattern in contact with the table and the mandrel, while the latter revolves, the edges of the work will be shaped and finished at the same time. By substituting a conical cutter for a cylindrical one, the work may be beveled; by using both, the edge may be made smooth and square, while the corner is beveled.

The tool shown in Fig. 157 might properly be called a barrel saw. It is made by drilling in the end of a



FIG. 157. Barrel Saw.

steel rod and forming the teeth with a file. To avoid cracking in tempering a small hole should be drilled through the side near the bottom of the larger hole. To insure the free working of the tool it should be turned so that its cutting edge will be rather thicker than the portion behind it. This tool should be made in various sizes.

EASILY MADE SLIDE REST

While the most of the work to be done on the foot lathe may be accomplished as expeditiously and quite as well without a slide rest as with it, yet there are some operations that are greatly facilitated by means of this tool. Boring, for example—a very difficult thing to do with hand tools—may be done quickly and accurately by using a slide rest. In gear cutting—described in another part of this section—a slide rest is essential.

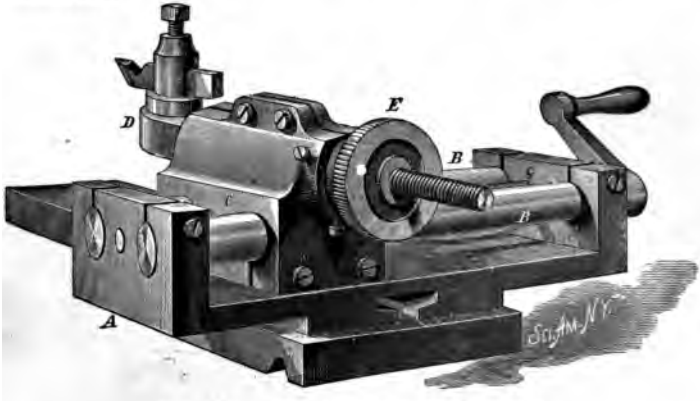


FIG. 158. The Complete Slide Rest.

In the case of this tool, as well as others previously described, the purchase of a well-made article is recommended. Yet, if one has time and feels so inclined, he may make a really efficient slide rest with no other tools than his lathe and ordinary turning tools. Figs. 158 to 160 inclusive represent a slide rest that may be made in this way, Fig. 158 being a perspective view, and Figs. 159 and 160 respectively longitudinal and transverse sections of the tool carriage.

The T-shaped casting, A, has a longitudinal slot, which is made T-shaped in cross section to receive the head of the bolt that confines it in position upon the plate fitted to the lathe bed. The vertical ears at opposite ends of the casting are bored to receive the ends of the rods, B, upon which the tool carriage, C, slides.

The first operation in making the slide rest is to make one side of the casting, C, perfectly plane. It is

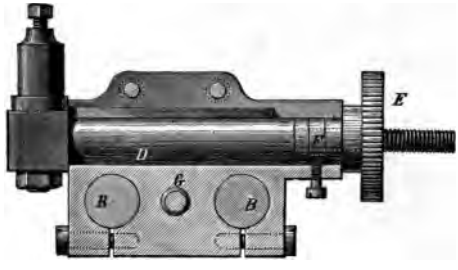


FIG. 159. Longitudinal Section of Slide Rest.

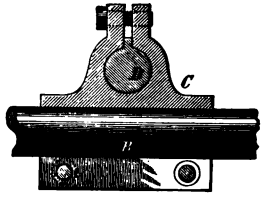


FIG. 160. Transverse Section of Slide Rest.

then chucked in the lathe with the plane side next the face plate. Three holes are bored through it, two for the rods, B, and a smaller one for the screw, G. It is then chucked on an angle plate, so that the holes for the rods, B, are equally distant from the center line of the lathe, and the hole for the rod D, is bored very carefully to insure the parallelism of its sides. The casting, A, is now placed upon a plane surface, and the

casting, C, is clamped to the ear at one of its ends, and adjusted so that a line drawn through the center of the holes is exactly parallel with the bottom of the casting. The casting, C, is used in this manner as a template for drilling both of the ears for the reception of the rods B. It will be necessary to exercise great care in drilling these holes, as it is of vital importance to have the rods, B, perfectly parallel.

The casting, C, may now be tapped to receive the screw, G, and the tool-carrying bar, D, may be fitted to its place, and turned down and threaded to receive the internally threaded boss of the wheel, E. This boss is fitted to the base of the casting, C, and is grooved circumferentially to receive a split ring, F, the latter being drilled to receive the ends of three screws that project through the casting into it and prevent the boss of the wheel, E, from moving lengthwise of the hole, while the arrangement permits of the free rotation of the wheel. The bar, D, has a head which is drilled vertically to receive the tool post, and is provided with a heavy feather at the top, which is received by the slot formed by sawing into the upper portion of the casting, C. To render the bearing of the bar, D, somewhat adjustable, two screws pass through the casting above the feather. The tool post is of the usual description, having a loose collar above the head of the bar, D, and a nut below it. The mortise for receiving the tool extends a little below the loose collar, so that when the tool is clamped the post and ring will also be clamped. A slot is cut through the bottom of the casting, C, into each of the guide rod holes, to permit of adjustment in case of wear by means of the screws which pass transversely through the slot. The ends of

the rods, B, are fastened by a similar device. The screw, G, is prevented from end motion by a shoulder on the outside of the ear at the crank end, and a collar on the inside. The rods, B and D, may be made of steel or of cold rolled iron; the latter will be true enough without turning. The casting may be either of brass or iron; a good quality of iron will perhaps prove the most satisfactory. The slots may be cut with the

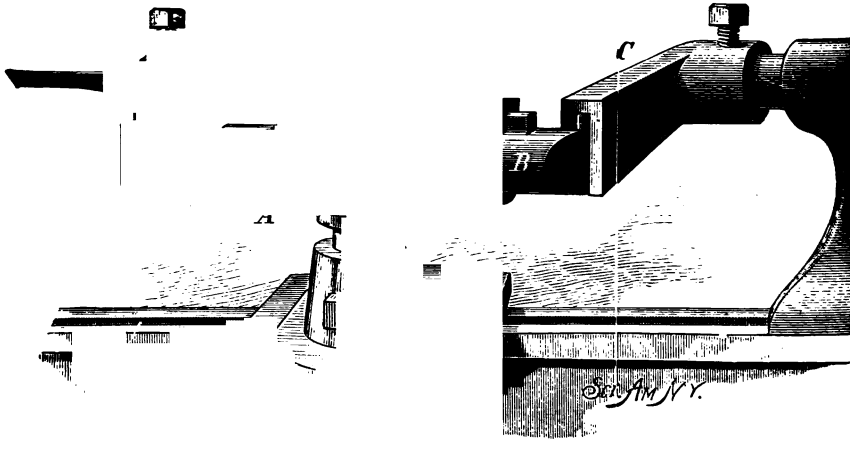


FIG. 161. Boring Attachment.

saws described in a former article. The tools to be used with the slide rest have also been previously described.

In Fig. 161 is represented a boring device which will be readily understood without special description. The casting, A, is fitted to the tool rest socket and provided with a sliding bar, B, which is like the bar, D, in the slide rest above described, excepting that its back end

is rounded and provided with a pin which slides in the slotted arm attached to the tail spindle of the lathe by which it is moved, instead of having a moving device of its own. With this tool, boring and some kinds of outside turning may be done. It is less expensive than the slide rest and answers a good purpose. It is probable that in making both these tools the services of a mechanic provided with a planer or shaper will be required.

INDEX PLATES FOR GEAR CUTTING

There are many amateurs who would make their own gear wheels were it not for the expense of purchasing or the trouble of dividing and drilling the index plate, which is the principal item in the apparatus required in cutting small gears.

Of course an index plate may be purchased, but the money thus laid out would go a long way toward paying for cutting all the gears that would ever be required by most amateurs.

It is admitted that it is difficult to obtain absolute accuracy by ordinary methods, but the plans here suggested will probably give as nearly perfect results as can be obtained without copying another index plate or using a dividing engine.

The index plate, before being divided, should be nicely turned and fitted to the place it will occupy on the lathe. This will generally be on the larger side of the cone pulley.

Two methods of graduating an index plate are illustrated by the accompanying engravings. One con-

sists in locating the holes by using paper scales which are printed from engine divided plates, and are, therefore, very nearly accurate. The other consists in dividing the plate by aid of a large paper disk graduated by hand.

For the most of purposes four rows of holes will answer. The best number of holes for the different rows is as follows: 240, 200, 144, 132. 240 can be divided as follows: 120, 60, 48, 40, 30, 20, 15, 12, 6. With 200 divisions: 100, 50, 40, 25, 20, 10 and 5 may be made. 144 divides into 72, 48, 36, 24, 18, 16, 12, 9, 8, 6. 132 into 66, 44, 33, 22, 11.

The best method of dividing an index plate of which the writer has any knowledge, aside from duplicating another, or using a dividing engine, is shown on the next page. A wooden block, A, is attached to the face plate of the lathe by means of screws, and turned down truly on the face and upon the edge. A portion of the edge is turned to a suitable diameter for receiving a certain length of paper scale, C. The other portion of the edge is pressed by a brake shoe, F, which is kept up by a screw in the standard, D. An index, E, is slotted and secured to the top of the standard, D, by a screw. To the face of the block, A, is secured the index plate, B, and in front of the plate there is a drill support which takes the place of the ordinary tool rest. The drill is capable of longitudinal as well as rotary motion in its support; it is driven by a belt from the drive wheel of the lathe, and is pushed forward a limited distance by the handle swiveled to the end of the drill spindle. The size of the drill will be governed altogether by the size of the plate; but in any case it should be as large as possible, always bearing in

mind that the space between the holes should be of sufficient width to insure the required strength.

That portion of the wooden block, A, which receives the paper scale, C, is carefully turned so as to permit the ends of the scale to abut; the scale being very carefully cut so that its ends will join accurately and render

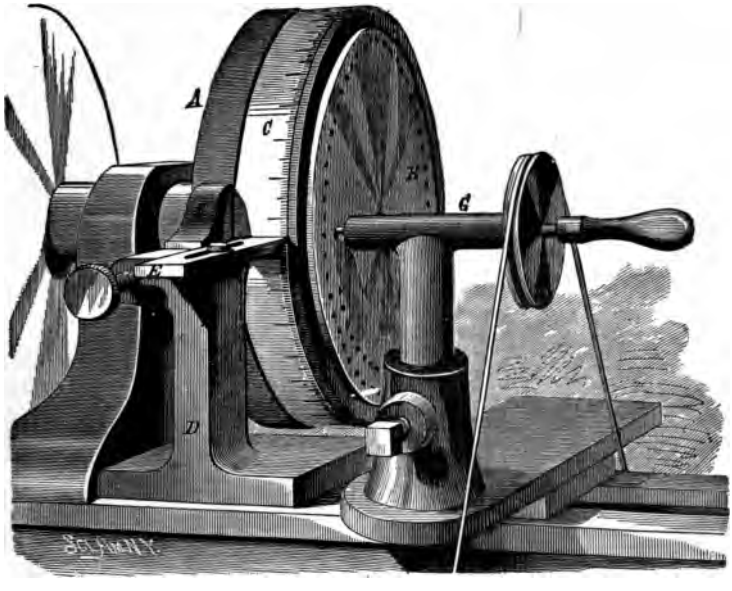


FIG. 162. Method of Graduating Index Plates.

the graduations of the scale uniform throughout. The scale is best attached to the block by means of paper tacks or small screws. For the greatest number of graduations given above, a two foot paper scale, or two pieces of shorter scales, will be required. The inches should be divided into tenths. The block should be 7.64 inches in diameter where it is surrounded by

the scale. The diameter of that part engaged by the brake shoe is not limited to any particular size.

It is obvious that for drilling 240 holes every mark on the scale must be brought opposite the index, E, and stopped by means of the brake, F, while a hole is drilled. After drilling this row of holes, the row containing 144 holes should be drilled, leaving a space between it and the 240 row for the 200 row. For the 144 row the operation is the same as that already described, except that a scale divided into twelfths is used, and alternate graduations only are noticed. The intermediate ones should be crossed out, so that the scale will really be a scale of inches divided into sixths. For the 132 row the block is turned down to 7 inches diameter, and the scale last used is shortened to 22 inches and again applied to the block and used as before.

After completing these rows of holes the drill is moved to the space between the first and second rows, the block is turned down to 6.36 inches, and 20 inches of the paper scale first used (inches divided into tenths) is employed. Every graduation on the paper scale is used in this case as in the first instance. This gives 200 divisions.

The paper scales recommended for this purpose are those used by engineers and draughtsmen. They may be obtained for a few cents from any dealer in mathematical instruments.

In Fig. 163 the larger circle represents a disk of paper which is carefully divided into large spaces by means of ordinary dividers, and the large spaces are subdivided in the same way.

In the center of the paper disk is placed the plate to

be divided, and from the center of the plate rises a stud, to which is accurately fitted the sleeve attached to the end of the radius bar. The radius bar extends beyond the outer circle on the paper disk, and carries an adjustable sleeve, to which is accurately fitted a

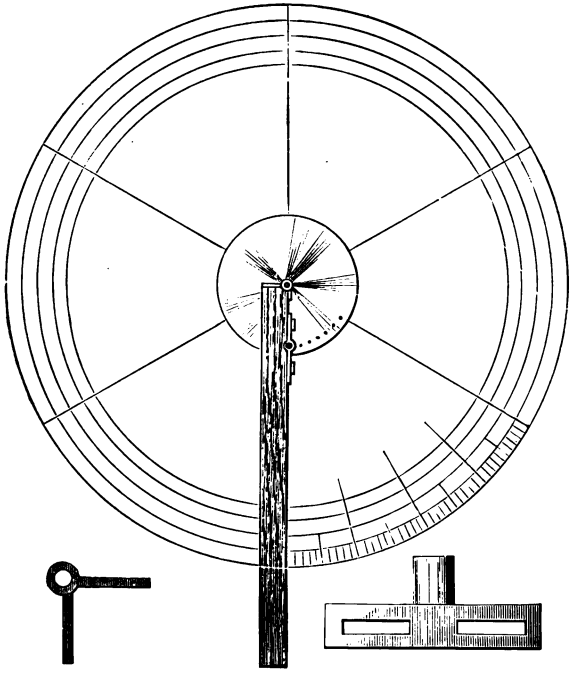


FIG. 163. Index Plates for Gear Cutting.

drill which may be rotated by means of a small drill stock. The sleeve that forms the bearing of the radius bar is shown in detail in the lower left hand corner of the engraving, and the sleeve that receives the drill is shown in the opposite corner.

While drilling, the radius bar is held in place by a

weight or by means of a clamp. After drilling each hole the bar is moved forward one space and secured by the weight or clamp. When one row of holes is completed, the sleeve which guides the drill is moved toward the center of the disk, and the operation of drilling is carried on as before. By this method whatever errors may exist in the graduations on the paper disk are greatly reduced in the index plate, and the plate produced will be accurate enough for most purposes if the work on the paper disk has been carefully done. The smallest plate should be at least three-sixteenths of an inch thick, and the holes should not be drilled quite through. Either iron or brass may be used for the disk. The latter works the easiest and will answer every purpose.

GEAR CUTTING APPARATUS

The index plate, A, is attached to the larger of the pulleys on the mandrel of the lathe by means of three or four screws, and the stop, C, provided with a point well fitted to the holes in the plate, is held in position on the bed plate, B, by a screw passing through a slot in the foot into the bed piece. The stop, C, is capable of springing sufficiently to admit of withdrawing the pin from the hole in the plate, and it is strong enough to hold the plate without vibration. Two standards, G, mounted on the plate, B, support pulleys over which the driving belt runs. The gear cutter head consists of a casting, D, fitted to the tool post of the slide rest, and the mandrel, E, provided with a pulley and mounted on carefully fitted centers in the casting. The casting, D, has upon opposite sides, near the upper end, ears (as shown in Fig. 165) for receiving the pulleys,

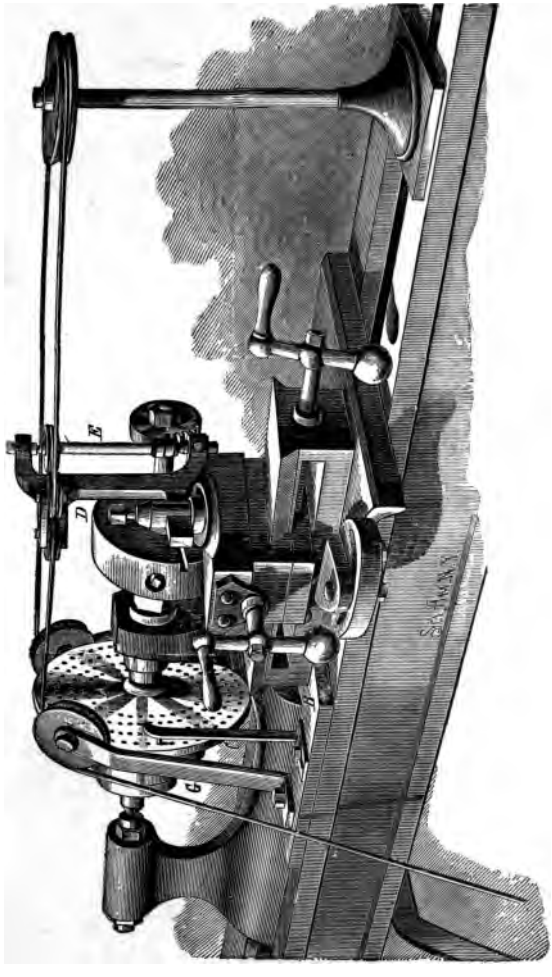


FIG. 164. Apparatus for Gear Cutting.

a b, which guide the driving belt, so that the cutter may be removed across the face of the wheel being cut without changing the tension of the belt. The extreme end of the loop formed by the belt is supported

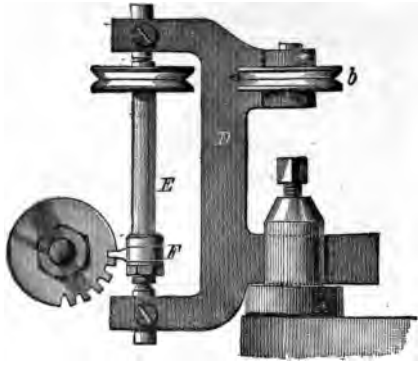
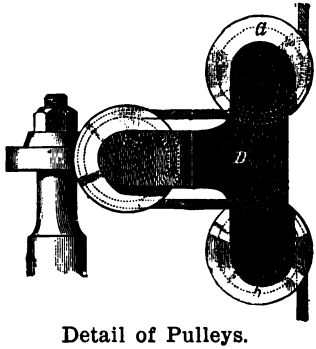


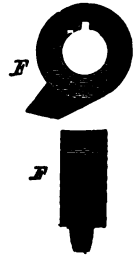
FIG. 165. Detail of Gear Cutter.

by the pulley, H, mounted on a standard rising from the lathe bed. The standard may be placed far enough from the slide rest to admit of putting the tail stock between it and the slide rest in case it should be necessary to use the tail stock for supporting the work.



Detail of Pulleys.

FIG. 166.



Cutters.

The mandrel, E, is provided with a collar and a nut for clamping the cutter, F. It will be noticed that the cutter comes exactly opposite the line of the lathe centers, and that it occupies about the same position, in relation to the tool post, that the point of an ordinary turning tool does. The cutter, F, is shown in Fig. 166, enlarged. The upper view represents the side, the lower view the edge of the cutter. It has but a single tooth and is adapted to brass and similar alloys only. It may be sharpened by grinding. When iron or steel is to be cut the cutter should have several cutting edges, and the mandrel, E, should have a larger pulley, as more power will be required and the speed must be slower. By setting the slide rest at an angle bevel gears may be cut.

HINTS ON MODEL MAKING

It is a simple matter for an experienced instrument maker or machinist to produce a fine model with turned shafts, cut gearing, true pulleys, and smooth working cams, but it is quite another thing for an inventor, without tools or materials, to embody his ideas in a working model even though he may have a mechanical taste.

It is fair to suppose that every mechanical inventor in these days of cheap machinery possesses some sort of a lathe, as these indispensable machines are now made for prices within the reach of almost any one.

It is quite evident, from an inspection of the models of the Patent Office, that most inventors who undertake to make their own models expend a great deal of labor without corresponding results. In the matter of

gearing, for instance, one will whittle his wheels in wood, another will borrow his gearing from some defunct clock, while still another will purchase ready-made wheels from one of our well known firms making a business of furnishing parts of models.

Of the three methods of obtaining the gearing the latter is undoubtedly the best, as all that is necessary to be done, in case of the cast gear wheels, is to bore them and file up the teeth, and as the cut gear wheels

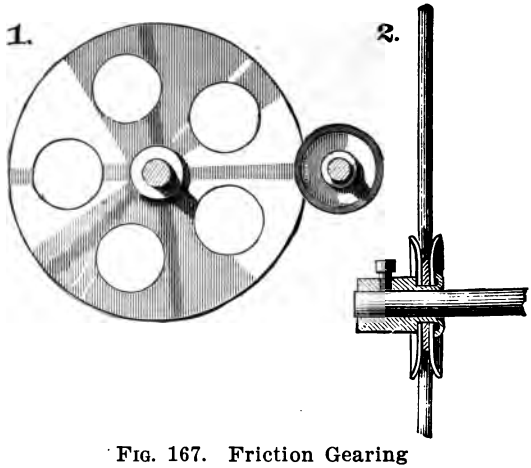


FIG. 167. Friction Gearing

are generally bored, the shaft may be fitted without further work on the wheels. It is, however, seldom absolutely necessary to use toothed gearing, as rotary motion may be readily transferred by suitable friction wheels or by grooved or sprocket wheels and a round belt.

Fig. 167 shows a form of friction gearing which is both simple and effective. The larger wheel is simply a disk of sheet brass having rounded edges, and boss

spun or soldered on, and a smaller wheel consists of two swaged disks of steel having their convex faces separated by a metal washer a little thinner than the large wheel. These three members are secured to a common boss by spinning the end of the boss partly over one of the disks, as shown in the sectional view, No. 2. This form of friction gearing is noiseless and runs strong enough for the requirements of almost any model.

Figs. 168 and 169 show a form of sprocket wheel

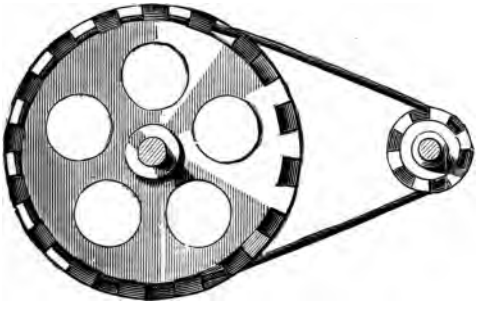


FIG. 168.

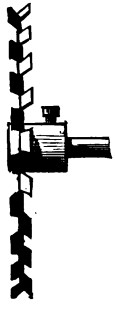


FIG. 169.

Sprocket Wheels.

which is readily made and is almost as positive in its action as gearing. In this case the two wheels are alike; they consist of disks of sheet metal nicked to a uniform depth from the edge, and the arms thus formed are bent alternately in opposite directions, forming a groove for receiving the round belt used in transferring motion from one wheel to the other. It is evident that a belt cannot slip on a wheel of this construction.

Fig. 170 shows a form of friction gearing for transferring motion at right angles, and for imparting a variable speed to a shaft from another shaft running at

a uniform rate. The large wheel in this instance is merely a plane disk of metal mounted in the manner already described. The smaller wheel is a grooved metal pulley surrounded by an elastic rubber ring. This is pressed with more or less force against the metallic disk, and its speed may be varied by moving it toward or away from the axis of the disk.

As to the matter of irregular motion usually imparted by cams, it is difficult to make a cam in the ordi-

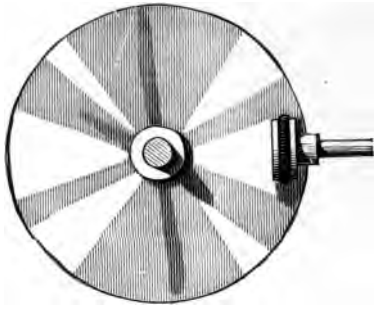


FIG. 170. Transferring Motion at Right Angles.

nary way with the milling machine, and there appears no very simple way of cutting them from solid castings. There is, however, a simple way of building them up from readily obtained materials.

Fig. 171 shows a cam consisting of a cylinder of brass or a short section of brass tubing provided with two heads and mounted on a shaft. The cam groove is laid out on this surface, and two parallel pieces of square brass wire are soldered to the surface of the cylinder, or fastened by means of screws. They are placed uniformly distant throughout the entire circumference of the cylinder.

Fig. 172 shows a cam built up in the same way on the face of a disk.

As to shafts, the model maker may save himself much labor and expense by using Stubbs' steel for small shafts, and cold rolled iron for larger ones. Either the steel or iron may be bought in one and three foot lengths.

Almost anything in the way of parts of models may be purchased ready for use, so that all the inventor need do is to combine them and mount them on a suitable

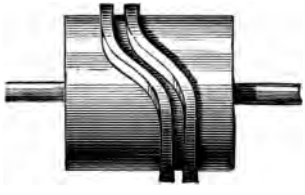


FIG. 171. Drum Cam.

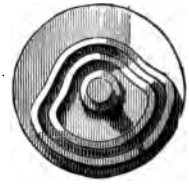


FIG. 172. Disk Cam.

frame; but even so simple a matter as a wooden frame for a model sometime proves troublesome.

The small tenons and mortises are difficult to make, and the frame to be strong enough to bear handling must be made so heavy as to be entirely out of proportion. A simple and easy method of securing the joints of small frames is to clamp the parts in the position they are to occupy in relation to each other, and then drill, with a sharp twist drill, two holes through one piece from side to side and into the end of the abutting piece, then inserting two hard wood pins, having previously coated them with glue. This makes a joint far stronger than the mortise and tenon, and it is very quickly done.

METAL SPINNING

The operation of spinning metals, although exceedingly simple and capable of being practiced to advantage in almost every shop, and also by the amateur mechanic upon the foot lathe, is not generally understood. One reason for this is that the artisans who follow this

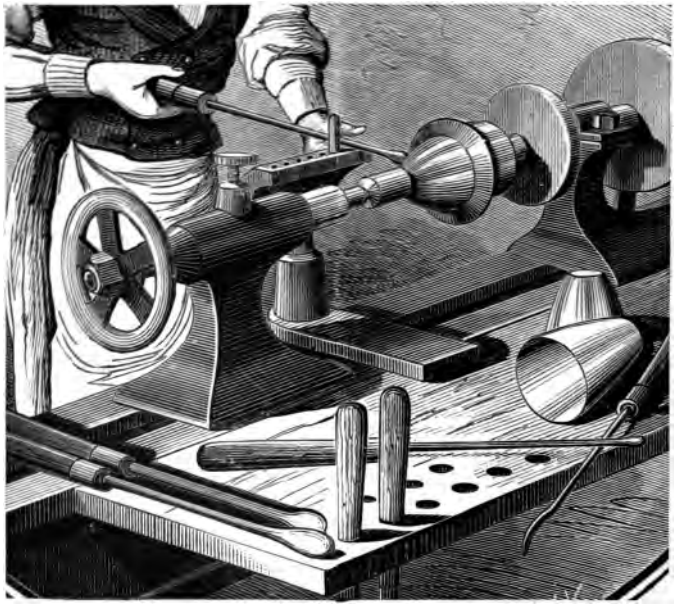


FIG. 173. Metal Spinning.

branch of mechanics as a business usually conduct it under locked doors, and it is with considerable difficulty that the amateur in search of information on this and kindred subjects can obtain entrance to one of these establishments. The reason of this secrecy is plain enough, as the "kink" or "wrinkle," or, in plain

English, the knowledge required to do the mechanical part of spinning is so slight that secrecy is the only protection.

The tools required are few. They consist of a lathe; a form or mould on which to shape the article; a tool rest with a series of holes for receiving a pin to keep the



FIG. 174.

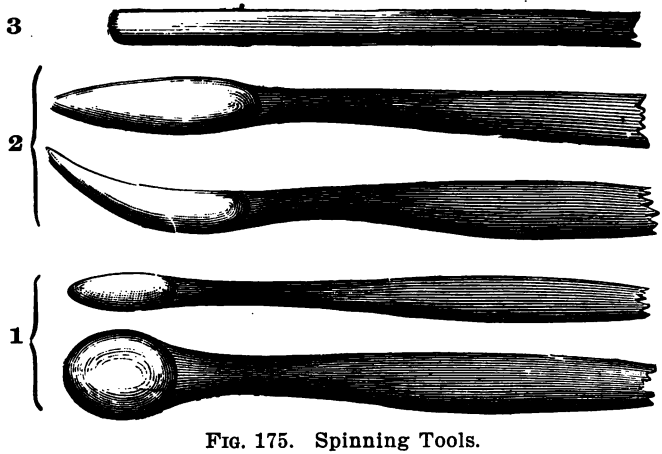


FIG. 175. Spinning Tools.

tool from slipping, and a few spinning tools or burnishers of different sizes and shapes.

The lathe the amateur is supposed to possess; the tool rest he may easily make; and the only other addition to the lathe will be a back center of the form shown in Fig. 174. This form of center answers as a step to the work holder, and will bear considerable pressure without undue friction.

The tools required are shown in Fig. 175. These are

simply hard steel burnishers of the form shown, and varying in size with the size and kind of work to be done. The size given in the engraving is about right for amateur work on a foot lathe. No. 1 shows in two

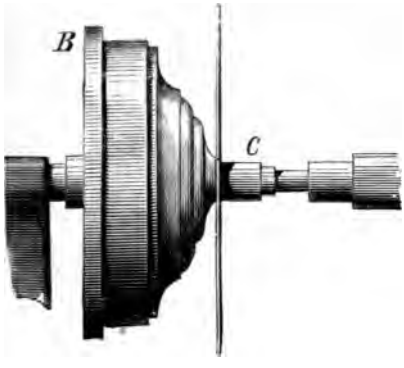


FIG. 176.

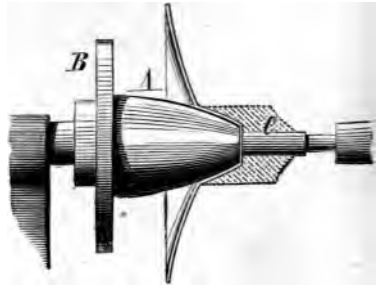


FIG 177.

The Forms in the Lathe.

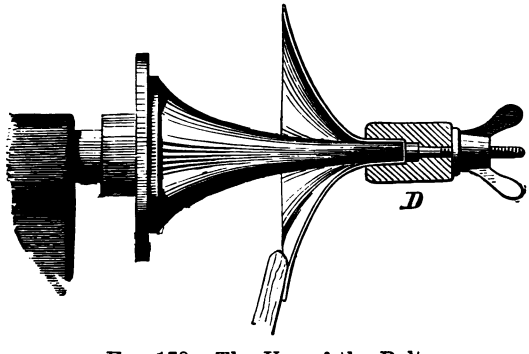


FIG. 178. The Use of the Bolt.

views a ball tool. No. 2 shows both side and edge views of a curved tool. No. 3 shows a plain round burnisher. In some instances it may be necessary to make tools of different forms. The operator will be guided in the selection of his tools by the particular work in hand,

and practice will bring new suggestions as to the tools and the manner of using them.

The materials generally used in spinning are brass, copper, zinc, britannia metal and lead. All of these may be worked on the foot lathe, but perhaps the ama-

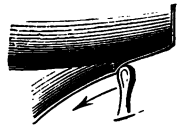


FIG. 179.



FIG. 180.

The Movement of the Tool.

teur will derive the most satisfaction at first by using britannia metal, as it works easily and does not require annealing. Articles in this metal also present a handsome appearance when done, whether simply polished

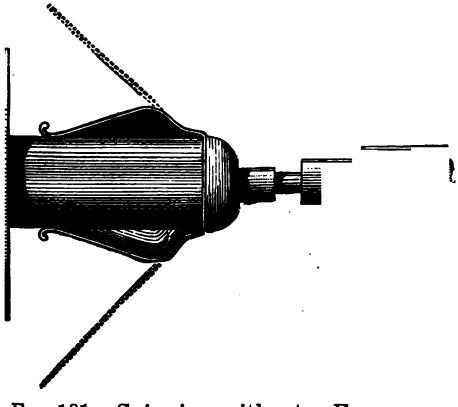


FIG. 181. Spinning without a Form.

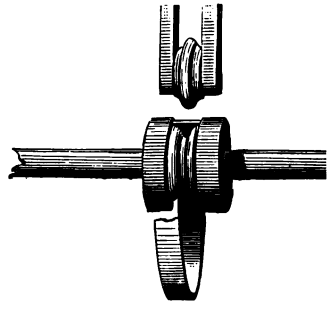


FIG. 182. Spinning a Ring.

or plated. Zinc must be spun quite hot. Articles of brass, if of considerable depth, must be annealed when partly done.

The form on which the metal is spun may be either hard or soft wood or metal. A good close grained pine answers as well as anything for most purposes, and is very readily turned to the required form. It may be attached to the face plate, B, and the disk to be spun may he held against it at first by a hard wood or metal piece, C, as shown in Figs. 176 and 177, which is forced against the disk by the tail center. After the spinning is a little advanced, a cup-shaped holder is applied, as shown in dotted lines in Fig. 177. Sometimes the



FIG. 183. Concave Reflector.

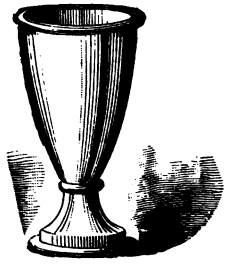


FIG. 184. Cup.

holder is secured by a bolt that runs through both it and the form or mould, as shown at D, Fig. 178. In some cases a little rosin is applied to the form to increase the friction, but this is rarely necessary. The motion of the lathe should be quite rapid, and the disk should receive a coating of grease (lard or heavy oil) before applying the burnisher. A very strong solution of soap may be used instead of oil. The position of the workman and the manner of holding the tool may be seen in Fig. 173. It will be noticed that the pin in the tool rest serves as a fulcrum for the tool, which must be brought with considerable pressure against the sur-

face of the disk. This pin is moved forward from time to time as the work advances. The movement of the tool may be seen in Figs. 179 and 180. The shape taken by the metal in front of the tool will also be seen. In swinging the tool toward the form it is moved in the



FIG. 185. Vase.



FIG. 186. Ball



FIG. 187. Pitcher.

direction of the arrow as shown in Fig. 179, and it is carried back as shown in Fig. 180. This last operation is very essential to the proper fitting of the mould, and it also thickens the metal. Too much should not be attempted at a time. A succession of quick movements, as indicated in Figs. 179 and 180, under a moderate pressure is much better than to do a great deal of execution at a single stroke. Should the metal tend to

vibrate or buckle, a piece of wood may be applied to the back with the left hand, as shown in Fig. 178.

The method of spinning a cup or pot without a form is illustrated in Fig. 181. Here the metal is supported by a plain cylindrical mandrel, and is first spun into



FIG. 188. Card Receiver.



FIG. 189. Vase.

the form indicated by the dotted lines, and then bringing the burnisher on the return stroke only to the shoulder which forms the larger part of the vessel. For small work on the foot lathe the handles of the tools need not be as long as represented, in Fig. 173. The length commonly employed for wood turning tools will answer.

To spin a ring, a mandrel like that shown in Fig.

182 will be required. A plain flat ring placed between the shoulders of the mandrel is pressed upon by the roller seen above the mandrel until the ring assumes the desired form. Napkin rings are made in this way.

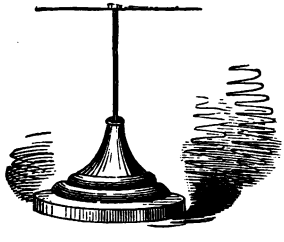


FIG. 190. Base.



FIG. 191. Vase.

Fig. 183 shows a concave reflector. Fig. 184 represents a simple cup formed of two pieces. Fig. 185 represents a small vase made of three pieces, the smaller end of the upper or conical part and the upper portion of the

base piece being soldered in a spherical connecting piece. The two halves of the ball, Fig. 186, are made upon the same form. The edges are beveled and soldered together. The pitcher, Fig. 187, is made of five spun pieces, a short cast and turned piece that unites it to its base, and a handle made of square wire. The card receiver, Fig. 188, has a spun top and base, and a cast standard. The vase, Fig. 189, consists of four spun pieces and three legs of square wire, uniting the body with the base. Fig. 190 shows a base for a magnetic needle or other small apparatus. Fig. 191 represents a vase composed of seven spun pieces and two handles of square wire. More complex examples of work done by the process of spinning might be furnished. The ones given are undoubtedly sufficient to enable the amateur to get an idea of the endless variety of articles that may be made by this simple and easily acquired art.

PART IV.

MODEL ENGINES AND BOILERS

A HOME-MADE STEAM ENGINE

A STEAM ENGINE carefully made is a piece of mechanism to be proud of, no matter what its particular design may be. A double-acting engine of good proportion, with a bored cylinder and forged crank and crank shaft, and other parts made in keeping, is, of course, the better form of steam engine to make, but, as we are presuming that not every amateur has the facilities for building such an engine, a description of a simple single-acting engine which could be made by any boy handy with tools is given. It can be made with an ordinary light foot lathe, as no boring is required, nor is there any turning to be done that does not come within the range of such a lathe.

A view of the engine and the boiler and engine is given, and also a sectional view showing the construction of the valve and valve-operating cam, and the steam passages in the base.

The cylinder consists of a piece, *A*, of mandrel-drawn steel tubing (which needs no boring) $2\frac{1}{2}$ inches long and $\frac{1}{2}$ inch internal diameter. The thickness of the metal forming the tube is $\frac{1}{16}$ inch. This piece of tubing is fitted to a boss, *a*, about $\frac{1}{8}$ inch high, formed on the brass block, near one end. This block is $1\frac{1}{2}$ inches long and $\frac{1}{2}$ inch thick, and is provided with lugs for receiving screws, by which it is attached to the base plate. In this block are formed the steam

passages, *b c*, and valve chamber. This hole drilled from the front backward and forming the passage, *b*, receives the steam supply pipe, *B*. A hole is drilled from the rear end of the block forward to a point about opposite the center of the cylinder, forming with the hole, *d*, the steam duct, *c d*. Near the rear end of the block is drilled a $\frac{5}{16}$ inch hole, from beneath, which forms the valve seat, *e*, just beyond the passage, *b*. A $\frac{3}{16}$ inch hole is started at the valve seat, *e*, and continued to the top of the block. This smaller hole is counter-bored from the top with a $\frac{5}{16}$ inch drill, leaving the valve chamber. The counter-bored portion of this hole receives the plug, *f*, which is bored longitudinally to receive the valve stem, *g*, of the conical valve, *e'*. The valve stem is about $3\frac{1}{4}$ inches long, and is provided with the adjustable collar, *h*, between which and the plug, *f*, is placed a spiral spring which tends to keep the valve normally closed. The steam passages, *b* and *c*, are closed with screw plugs, as shown.

To the steel tube which forms the cylinder is fitted a piston of cast iron. It is about $1\frac{1}{8}$ inches long and is packed by the steam or water contained in the grooves in the piston. The upper end of the piston is slotted to receive the lower end of the connecting rod, which is pivoted therein upon a $\frac{1}{8}$-inch pin passing through the piston and lower end of the connecting rod, as shown in dotted lines in the sectional view.

The brass block which supports the cylinder has lugs on opposite sides receiving screws which pass through them into the base plate. This plate is 4 inches wide, 5 inches long and $\frac{1}{8}$ inch thick. At the rear of the valve chamber is a post formed of a $\frac{1}{2}$-inch square brass rod $4\frac{3}{8}$ inches long, secured to the base

plate by a screw passing upward through the plate into the end of the post. A similar post is placed near the rear end of the base plate. The ends of the posts are squared in the lathe. Both posts are bored trans-

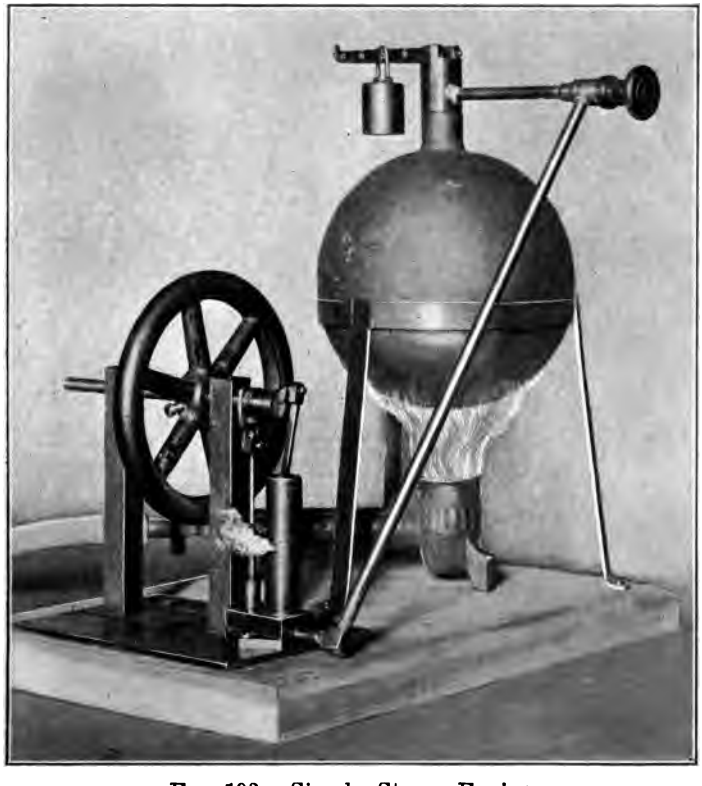


FIG. 192. Simple Steam Engine.

versely near the top to receive the shaft, which is $\frac{1}{4}$ inch in diameter and 5 inches long. The space between the posts is 2 inches, and the distance between the shaft and base plate is $3\frac{7}{8}$ inches. On the shaft, between the posts, is placed the iron fly-wheel, which in

the present case consists of an old valve wheel 4½ inches in diameter, bushed to fit the shaft and fastened with a set screw.

The end of the shaft which projects beyond the post over the cylinder carries a ½-inch crank on which is placed a connecting rod. This rod measures 1⅝ inches between the centers of the holes for the crank pin and the pin in the piston.

In the side of the cylinder are drilled three 1/16 inch holes in a horizontal line, and close together to form the exhaust port of the engine, which is entirely uncovered by the piston when it is in the position shown in the engraving. The exhaust remains open for about a quarter of the revolution. This port is left exposed for clearness, but it may be covered by a hollow ring which encircles the cylinder and receives an exhaust pipe.

On the left shaft is placed a cam, in whose boss there is a circumferential groove, and upon the upper end of the valve stem is placed a fork, the upper ends of which slide in the groove in the boss of the cam. A stud inserted in the fork has upon it a roller which rolls on the higher part of the cam and opens the valve at the proper instant. This cam opens the valve just before the piston reaches the lower limit of its stroke, and allows the valve to close just before the exhaust is opened by the piston.

The boiler of this engine consists of a copper float to be found in the market, made by an electrolytic deposit of copper. Such a float forms a seamless boiler capable of withstanding a great pressure, say 100 pounds. The boiler is mounted in a tripod made of band iron and is furnished with a safety valve ¼ inch

in diameter, the lever of which is about 2 inches long, and graduated and weighted so that it will blow off at 35 pounds, thus insuring perfect safety. (The ordinary copper float is not recommended.) A brass steam pipe, $\frac{1}{8}$ inch internal diameter, is screwed into the safety



FIG. 193. Simple Steam Engine.

valve casing below the valve sat, and has at its end a miniature angle valve which is connected to the engine by the inclined pipe, and by elbow and nipple which extends into the base. As the angle valve is a troublesome piece of work, an ordinary stop cock is recom-

mended in its stead. It should be placed in the inclined pipe.

The best burner for this boiler is an Argand gas Bunsen burner like that shown. Of course an alcohol lamp will answer, but it is not as safe as the gas burner.

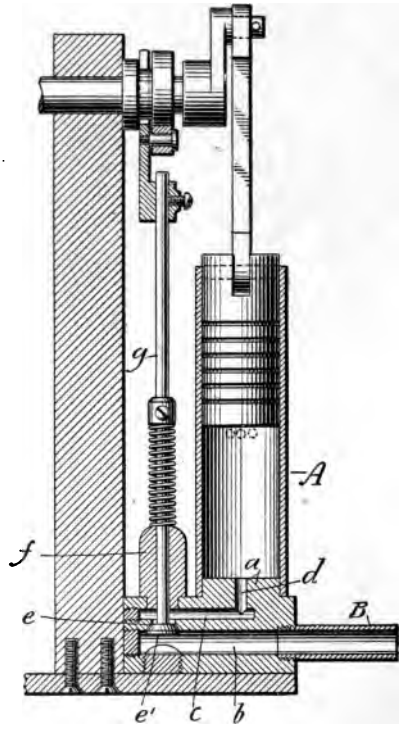


FIG. 194. Sectional View of Engine.

Both engine and boiler should be mounted on a suitable base board.

The engine is capable of making a thousand or twelve hundred revolutions per minute. It must be well balanced for this speed.

The boiler is filled when cold through the safety valve opening by means of a funnel having a slim corrugated tube. The boiler should be about two-thirds full of water at the start.

It is obvious a larger engine could be made on the same principle; but the front support for the shaft should be made A-shaped and placed next to the crank, and the cam should be placed between the support and the fly-wheel; the shaft support would then extend over the cylinder-base.

A SAFE WAY TO RUN A SMALL ENGINE

Almost every youth at some time in his life has coveted a steam engine, or some other motor having energy and ability to move of itself and to impart motion to other machines, but through fear of fire from the lamp used to generate steam, or anticipating possible explosions, has been obliged to forego the pleasure of being a boy engineer, and seek amusement in other directions. Every boy can own a steam engine, since one can be purchased for 50 cents, $1, $2 or more, and the engine can be run with safety by means of compressed air. Any engine that will run by steam will run equally well with compressed air.

But how is the compressed air to be furnished and stored for use? There are very few families without bicycles, and every bicycle requires a pump for inflating the tire; why not use the same pump to compress air for an engine? The boiler constitutes a small reservoir, and an auxiliary reservoir may be connected with the boiler by means of a small rubber tube. The auxiliary reservoir may consist of a piece of strong

3-inch galvanized iron leader, with caps soldered on the ends, with a small tube inserted at any convenient point to receive a bicycle valve, and another small tube to receive the piece of small rubber tubing which forms the connection between the reservoir and the engine or the boiler belonging to the engine.

This boiler and reservoir when pumped up as much as possible by ordinary exertion, will run the engine while driving the boat for about 15 minutes. The caps to the reservoir mentioned are made conical so that the reservoir may be drawn in the water after the boat, the connecting rubber tube forming the hawser for towing the reservoir.

If it is desired to run a stationary engine with compressed air, the reservoir may consist of a tin can. A 1-gallon varnish can answers very well, but it can be forced out of shape and even exploded unless it is encased in a strong wooden box fitting it closely and put together with screws.

A MINIATURE CALORIC ENGINE

The hot air engine is not a very recent invention. A number of engines of this class, of different sizes, were devised and used in the early part of the present century, and in the latter part of the last century there were in existence engines constructed to be operated by the expansion of air.

Nothing in the way of a motor, aside from a windmill or water wheel, can be more simple than this, and it is a pity that it is not capable of more general application. Motors of this kind have been used to some extent for driving light machinery, and they have been largely employed in pumping water.

Quite recently caloric engines have been made in the form of a toy, as illustrated in the following engraving. In the motor here shown, the air contained in the expansion cylinder is alternately heated and cooled, and no fresh air is introduced. This action is so rapid



FIG. 195. Small Caloric Engine.

in a small engine that the crank shaft can make 600 or 700 revolutions a minute. By examining the sectional views (2, 3 and 4, Fig. 196) a good idea of the construction and operation of the motor may be obtained. In

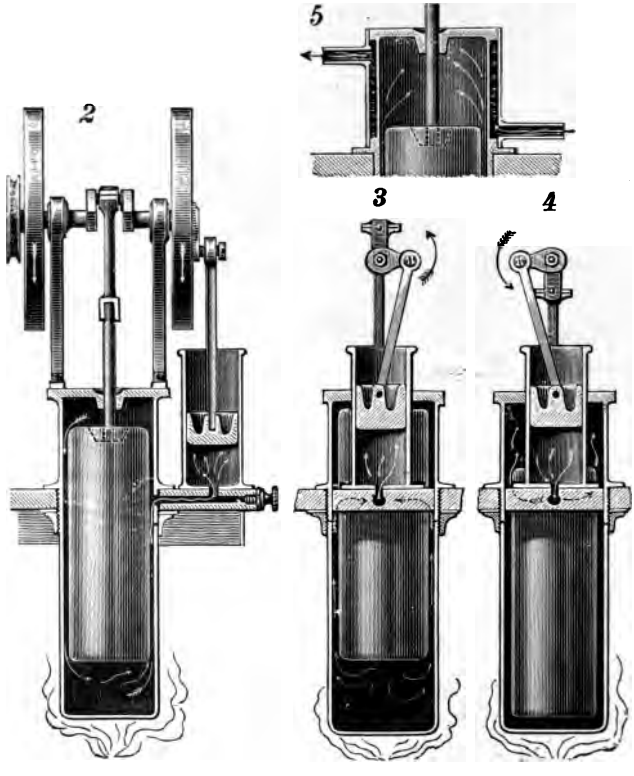


FIG. 196. Sectional Views of Small Caloric Engine.

brief, the larger and longer of the two cylinders (the expansion cylinder) contains a long, hollow piston called the "transfer piston" which fits the cylinder very loosely. To this piston is attached a rod extending through a close fitting sleeve in the top of the cylinder,

the piston rod being provided with a connecting rod fitted to the crank at the middle of the shaft. The upper part of the expansion cylinder is furnished with a wide flange forming a cap which fits over the sheet iron fire box, and to the top of the expansion cylinder are secured the standards in which is journaled the crank shaft.

To the flange is attached the power cylinder, which is shorter and smaller in diameter than the expansion cylinder. This cylinder is provided with a piston to which is pivotally connected the lower end of a connecting rod, the upper end of which receives a crank pin projecting from one of the fly wheels at right angles to the transfer piston crank. A hole bored in the flange connects the expansion cylinder and the bottom of the power cylinder, as shown in No. 2, Fig. 196, and the outer end of the hole is stopped by screw plug which can be removed for cleaning the hole, should it become stopped by oil or otherwise.

An alcohol lamp is provided for heating the expansion cylinder, it being placed in position to heat the lower end of the cylinder, as shown in the larger view. The top of the lamp is provided with a hemispherical cavity, at the bottom of which is the aperture for filling. The stopper consists of a marble dropped into the hemispherical cavity and serving the double purpose of stopper and safety valve.

The expansion and power cylinders contain a certain amount of air which is never changed during the operation of the engine, except by expansion and contraction. Heat having been applied to the lower end of the expansion cylinder, the engine is started by giving the crank shaft one or two turns in the direction indi-

cated by the arrows on the rims of the fly wheels. The air at the top of the expansion cylinder is transferred to the lower end of the cylinder by the transfer piston as it rises; at the same time the power piston descends, and by this time the air is heated in the lower part of the expansion cylinder and begins to expand. The power piston is in position to be pushed up by the air pressure. As the power piston reaches the upper end of its stroke, the transfer piston descends and transfers the heated air to the upper end of the expansion cylinder, where it is cooled, thus reducing the pressure and allowing the power piston to descend again. This operation is repeated at every stroke. It is almost impossible to believe that the air can be heated and cooled so rapidly.

The efficiency of the motor can be increased by surrounding the upper portion of the expansion cylinder by a water jacket provided with a water supply pipe at the bottom and a discharge pipe at the top, as shown in No. 5, Fig. 196, and keeping a continual flow of cool water through the jacket. When the motor is used for pumping, the water is forced through the jacket.

This little motor is only a toy, but it very completely illustrates the principle of one of the most successful hot air engines ever devised. If the reader is mechanically inclined, he may make a motor on this plan on a much larger scale, and use it for driving machinery. There can be no doubt about its successful construction or operation, if it is made airtight and the bearings and friction surfaces are made to run free. The proportions may be about the same as shown in the cut.

The dimensions of the motor from which the views were made are as follows:

	INCHES
Length of expansion cylinder	$4\frac{3}{4}$
Internal diameter of expansion cylinder	$1\frac{5}{16}$
Length of transfer piston	$2\frac{13}{16}$
Diameter of transfer piston	$1\frac{1}{4}$
Length of power cylinder	$1\frac{3}{4}$
Diameter of power cylinder	$\frac{21}{32}$
Length of cranks	$\frac{7}{16}$
Diameter of fly wheels	3
Height of firebox from base	$5\frac{1}{2}$

AN INEXPENSIVE WATER MOTOR

A simple but very effective water motor can be made by any one according to the plan here shown, with little trouble or expense. It may be necessary to have a few minutes' work done by a tinsmith. The maker may do this if he understands soldering.

In a pine board 7 inches square and 1 inch thick, make a round hole 5 inches in diameter, by the use of a scroll saw, or in any other convenient way. To the sides of the board fit two thin boards $\frac{1}{4}$ inch thick, one on either side. In a small hole in the center of each side drive a short piece of brass tube of about $\frac{1}{8}$ inch internal diameter, and to these tubes fit a straight steel wire so that it will revolve freely. This wire is the shaft of the motor wheel. It should be of sufficient length to project an inch beyond its bearings, to receive a small pulley.

To the center of the shaft is soldered a sheet brass disk 3 inches in diameter, so that it will run true as

the shaft revolves, and to the disk is soldered a disk of brass wire gauze 30 mesh. The edges of the brass wire gauze must, as the ladies would say, be sewed over and over with a fine copper wire, to prevent it from raveling when the wheel revolves rapidly. If the workman is an adept he may solder a ring of brass wire, say No. 18 or No. 20, to the edge of the wire cloth.



Fig. 197. Motor Driving Sewing Machine.

The simplest way to secure a nozzle for the wheel is to buy a cheap, small oil-can having a long nozzle, with an opening in the smaller end of about $\frac{1}{16}$ inch. This nozzle is inserted into the edge of the wooden wheel-case, as shown, and its smaller end is bent so that it forms a small angle with the wheel, with the point of the nozzle as near the wire cloth as possible without touching. To cause the wheel thus made to keep a cen-

tral position in its case, pieces of the small tube before named may be slipped on the shaft each side of the wheel.

A ¾-inch hole may be made in the casing at the bottom, and provided with a short tube for receiving a rub-



FIG. 198. Small Water Motor.

ber pipe, to carry off the waste water, and there should be a ¼-inch hole in each side near the top to admit air. The casing may be secured to the wooden foot-pieces with screws. It is desirable to make the casing impervious to water. To do this, the various parts may be boiled in hot paraffine for ten minutes. If it is

found difficult to secure paraffine in bulk, a pound of paraffine candles will furnish enough for this purpose. The inflammable nature of paraffine should be kept in mind, and a cover should be provided for the vessel in which it is melted, so that it may instantly be extinguished by the cover should it become ignited. The metal used in the construction of this wheel should be of brass, excepting the shaft. The screws with which the casing is put together should be brass. The top of the oil-can is cut off to form a part of the coupling for receiving the rubber pipe leading from the wash-bowl faucet to the motor.

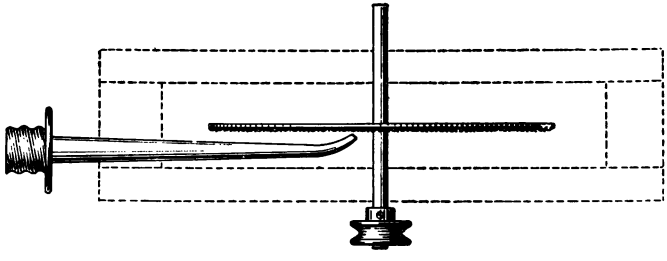


FIG. 199. Diagram Showing Position of Nozzle.

To prevent the checking of the wooden parts of the motor, the parts should be arranged with the grain lying in the same direction.

With sufficient water pressure, this motor will make from 1,500 to 2,000 revolutions per minute. With a very flexible cord belt—a leather shoestring, for example—it may be made to drive a light sewing machine, fan, or any other machine requiring a small amount of power

If more power is required than can be secured by one water jet, additional nozzles may be distributed around the wheel, or more wheels may be placed on the same

shaft, but nothing will be gained unless the water pressure is maintained. This pressure should be from 25 to 40 pounds per square inch.

In a small high-speed motor of the class here described, the full power is realized only when it is provided with a very small pulley connected by a very flexible belt with a large pulley on the machine to be driven.

It is obvious a non-corrosive metallic case would be better than a wooden one, and the metal one is advised when the builder has conveniences for making a casing of that kind.

PART V.

METEOROLOGY

SELF RECORDING INSTRUMENTS

IF these instruments were constructed so that each would produce a permanent record of its movements, it would certainly add to their usefulness as well as their convenience, but it is thought best to confine the construction to these simple forms of apparatus, trusting to the ingenuity of the reader to apply clock mechanism for keeping the records. One eight-day clock could be made to do duty for all the instruments. It could be geared to a drum so that it would make one revolution in one day, or in one week, and each instrument could be made to mark on a piece of paper carried by the drum. The paper would need to be graduated so that the pen carried by each instrument could be readily traced. There should be divisions for days and hours.

The pen by which the record is made is simply a small glass tube about $\frac{1}{8}$ inch in internal diameter, with the end which bears upon the paper drawn out to almost a capillary tube and cut off and made round and smooth by heating in a gas or alcohol flame. The ink used in this pen is a drop of red ink mixed with an equal amount of glycerine. This ink remains in the narrower end of the tube and does not evaporate.

METEOROLOGY

The subject of meteorology has claimed the attention of men to a greater or less extent doubtless since

the earth began to be inhabited by human beings. The phenomena of the air must have early attracted attention and caused the observers to reason from cause to effect until there came gradually to be an understanding of earth, air and water—not always correct—but in the main pointing to the present development of the science, so that after the lapse of many centuries, the close student of nature is able to explain various phenomena and to predict with more or less certainty what will happen, especially in the immediate future.

To be able to predict the weather with a little more certainty than the ordinary "weather prophet" can do, the student should be in communication with the Government Weather Bureau, so as to avail himself of the observations of others; but even without such facilities as these many interesting observations may be made with the simple apparatus hereinafter described, and notes may be kept for future reference.

This kind of observation is instructive in several ways. The very act of making frequent observations induces a methodical habit which will be valuable through life, and the observations are interesting and instructive in themselves. Besides all this, the record formed is likely to be valuable for both present and future use.

WHAT MAY BE LEARNED BY THE USE OF THE METEOROLOGICAL INSTRUMENTS

When we find the weather vane pointing toward the west we look for clear weather, and as a rule we are not disappointed; but when the vane indicates that the wind is blowing from the east, a storm is expected.

When it blows from the north, cool weather may be looked for, and when it blows from the south, it hardly ever fails to bring sultry days in summer and thaws in winter.

When the wind blows strong from any direction, curiosity is aroused as to the pressure it is exerting. This may be ascertained by observing the wind pressure gauge; 1⅛ pounds pressure shows that the wind is blowing fifteen miles per hour; 4½ pounds pressure per square foot represents a velocity of thirty miles per hour; 18 pounds pressure indicates a velocity of sixty miles an hour, and 50 pounds pressure is registered during a tornado one hundred miles an hour. In calculating the pressure as indicated by this gauge it must be remembered that the board which offers resistance to the wind has only a half square foot area.

The velocity of the wind is shown by the anemometer. Wind is hardly noticeable when it blows a mile an hour. When it blows five miles an hour it is a pleasant breeze; when it blows ten miles an hour it is a brisk breeze; when it blows at a twenty-mile rate it is a stiff breeze; at thirty miles it is a high wind, and at forty miles it is a very high wind. At eighty miles it is a hurricane, and at a hundred miles per hour it is a tornado.

THE WEATHER VANE

The weather vane hardly needs explanation to make it understood. In the top of a stout pole is inserted a ¼-inch rod which is bluntly pointed at its upper end. On this is placed a vane consisting of a wedge-shaped piece of hard wood with a hole through it, a

piece of hoop iron being fastened over the hole and resting on the upper end of the blunt-pointed rod.

To opposite sides of the wedge are secured pieces of ¼-inch board 4 inches wide and 20 inches long. These pieces are let into the faces of the wedge so

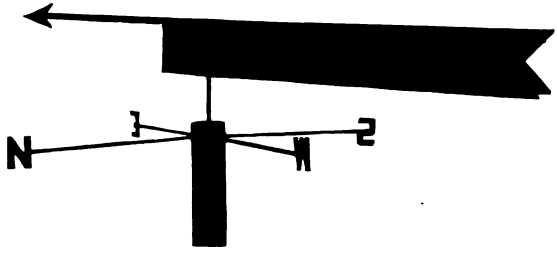


FIG. 200. Weather Vane.

as to form continuous surfaces. The boards diverge so that their free ends are about 2½ inches apart. This construction insures steadiness.

The thin end of the wedge has an arrow-headed arm projecting from it to indicate the direction of the wind. In the sides of the pole, near the upper end, are inserted four ¼-inch rods arranged at 90 degrees with each other, and in slots sawed in the ends of the rods are riveted letters which indicate the points of compass, N., S., E. and W. These, in connection with the arrow-headed arm, enable the observer to tell which way the wind blows.

WIND PRESSURE GAUGE

The construction of a wind pressure gauge is as simple as that of the ordinary windmill, which every boy knows how to make. A wind vane 6 inches wide and 24 inches long is made of a ⅞-inch board, on the

edge of which is secured a piece of band iron which projects over the end of the board about 1½ inches. In the end of the board are inserted two screw-eyes for receiving the rod upon which the vane swings. The upper end of the rod is pointed bluntly, so that the piece of band iron which rests upon it allows the vane to swing freely in any direction.

The middle portion of the board is cut away from the upper edge to admit of placing a spring scale for the measurement of the wind pressure. In the upper edge of the board at opposite ends of the scale-notch are inserted wire screw-eyes to receive the horizontal wooden rod which carries the wind-pressure board, 8 by 9 inches long and ¼ inch thick.

The board is stiffened by a cleat on the back, which is bored to receive the rod. A screw hook is inserted in the rod, and another is inserted in the upper edge

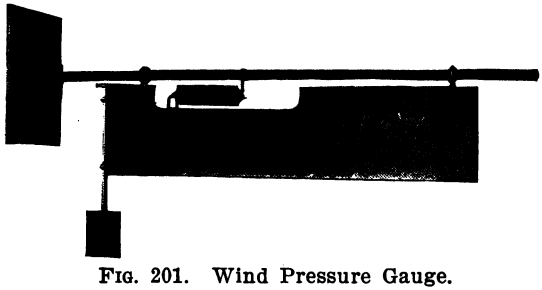


FIG. 201. Wind Pressure Gauge.

of the vane for receiving, respectively, the eye and hook of the scale. The spring scale is adjusted so as to hold the thin board a little more than the length of the slot in the spring-scale away from the pivot of the vane when the wind is light or nil. When the wind blows the vane keeps the instrument headed

toward the wind, and the scale indicates the pressure on a half square foot, so that the reading must be multiplied by 2 to secure a correct pressure.

The rod should be inserted in a rigid post and must be exactly vertical.

The amount of rain falling in a given time can be ascertained approximately by placing any kind of vessel having parallel sides out of doors in an open place where it may receive all the rain, and then measuring the depth of the water after the rain by means of a small stick plunged into it; the depth being registered by the wet portion of the stick. This method, however, is crude and open to objections; some of the water will spatter over, some will be lost by evaporation, and some will be displaced by the stick.

If the observer is really in earnest he should make, or have made, a copper vessel like the one shown in the illustration. It is 4 inches in diameter and 6 inches high, with the bottom set in 1 inch so as to receive the copper tube, which is bent twice at right angles, with its inner end inserted in the recessed bottom and its outer end extended up outside the vessel, and even with the bottom to receive a $\frac{3}{8}$-inch glass tube, which is cemented therein with a cement consisting of white lead paint and litharge formed into a soft putty.

The glass tube is 7 inches long, and furnishes a ready means of ascertaining the depth of water in the vessel when viewed in connection with the scale of inches attached to the vessel.

In the top of the vessel is inserted a funnel $3\frac{1}{2}$ inches long, with a cylindrical portion at the top 2 inches

deep. The upper and lower edges of the main vessel are wired to give them rigidity, but the cylindrical top of the funnel is not wired.

A rubber band may be stretched around the funnel at the junction of the cylindrical and conical portions to prevent waste by evaporation at this point. To



FIG. 202. Rain Gauge.

insure accuracy the copper pipe which holds the glass tube should be filled with water before the observation begins.

When the gauge is used in a windy place it should be clamped to some fixed object by three screws engaging the wire rim at the bottom of the vessel.

A METALLIC THERMOMETER.

A mercurial thermometer calls for manipulations which are not within the scope of the amateur, but require the skill and experience of the regular manufacturer. A metallic thermometer, however, is very easily made, and serves the purpose fully as well as a mercurial thermometer. It can be made as sensitive to the variations of temperature as may be desired.

It is made by placing together a strip of steel and one of brass 6 inches long, $\frac{1}{4}$ inch wide and $\frac{1}{32}$ inch thick. The ends of the strips are tinned for about $\frac{3}{8}$ of an inch at each end of their adjacent faces, and then put together and heated first at one end and then at the other, so as to solder them together at the ends.

The brass strip is made about $\frac{1}{4}$ inch longer than the steel strip, and is bent over and perforated to receive a silk thread as will be presently explained. Commonly, when strips of steel and brass are used in a compound bar, they are riveted at short intervals, to keep them from buckling. In the present case the compound bar is provided with a winding of soft wire (No. 30) which keeps the strips close together. To insure permanency the bars are drilled and riveted with a single rivet at each end.

The compound bar thus made is inserted in a round hole in the middle of a hard wood block $2\frac{1}{2}$ inches long, and held there by an ordinary wood screw inserted in the end of the block and clamping the end of the bar. The wooden block is secured to a base piece, 4 inches square and $\frac{7}{8}$ inch thick, having attached to it a back board $\frac{1}{4}$ inch thick, 4 inches wide, and about

10 inches high. A wire nail about $\frac{1}{16}$ inch in diameter and $1\frac{1}{2}$ inches long is driven through the back with its pointed end projecting about $1\frac{1}{4}$ inches. The nail is about $\frac{3}{4}$ inch from the upper free end of the compound bar. A paper roll is formed upon another nail or a piece of wire a trifle larger than the one used in the construction of the thermometer. The strip of writing paper used for this roller should be 1 inch wide and about 8 inches long. Enough of the paper is wound to make the roller $\frac{1}{4}$ inch in diameter. The paper, except the first layer, is pasted as it is rolled, so that it forms a solid paper roll when it is dry.

This roll, when dry, is transferred to the nail projecting from the back piece, and a pointer, or index, about $2\frac{1}{2}$ inches long is cut from thick writing paper and glued to the end of the roll. Then a silk thread is tied in the eye in the free end of the compound bar, and passed over the roller on the nail, and wound three times around the roll, and it has attached to it a small weight. In the present case this weight consists of a lead bullet split half open with a knife, and closed down upon the thread by pliers or by hammering. With every change in temperature the compound bar swings, so as to cause a movement of the index by the pulling or releasing of the thread and the raising or lowering of the weight.

The index should be placed in a vertical position when the temperature is about 70°; then the winding of the silk should be separated a little, and a small drop of mucilage should be placed on the middle convolution of the thread at the top of the roller, so as to cement it to the roller and prevent any change of adjustment.

A semicircular piece of bristol board, about 6 inches in diameter, is temporarily supported behind the index by a block glued to the back piece. The bristol board is to form the thermometer scale and is fastened to

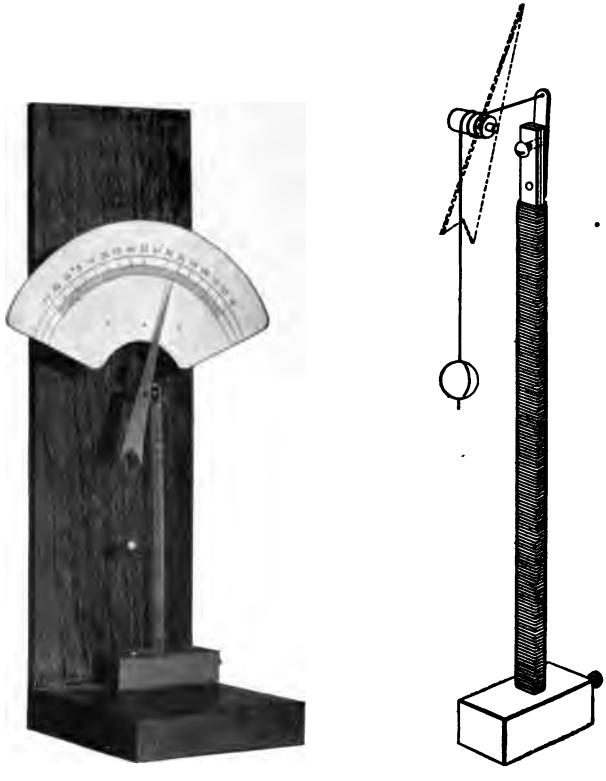


FIG. 203. A Metallic Thermometer.

the block by tacks or otherwise, so that it can be re moved and accurately replaced. A pencil mark is nov made on the scale at the point of the index which indi cates the temperature as shown by a mercurial ther mometer at the time. If it is 70°, the mark on the new

scale represents this temperature, and whenever the index points to this mark the observer knows the thermometer is 70°.

Now the thermometer is placed in a refrigerator along with a mercurial thermometer. They are left in the refrigerator for an hour, and then a pencil mark is made at the point of the index. This will, perhaps, be 40°. The space between these two marks is divided into thirty even spaces, representing as many degrees, or it may be divided into fifteen spaces, each of which will represent 2°. This graduated space serves as a guide for constructing the balance of the scale. If 2° spaces are used, twenty such spaces laid off on the left-hand side of the scale will extend the scale to zero. Twenty more such spaces will extend the scale to 40° below zero, which is lower than any temperature experienced in this climate. The space between 40° and 70° is already graduated, and the space above the 70° mark is graduated as described for the lower end of the scale. As each line represents 2°, 10° would be represented by five lines, so that the fifth line could be extended beyond the other lines for the sake of convenience in reading. Figures from 0° are placed opposite the long lines so as to read 10°, 20°, 30°, 40°, and so on, as in an ordinary thermometer scale.

The amateur can refine this thermometer as much as he pleases. He may, if he desires, place the entire device in a case and cover the dial with a glass, provided he furnishes several apertures to enable the air to circulate and thus keep the temperature the same as that of the external air. The free end of the compound bar may have a spring riveted to it, as shown in the detached view, and an adjusting screw may be inserted in

the compound bar so as to bear against the spring. With this construction, the silk thread may be tied in a hole in the free end of the spring, and the desired adjustment may be made by turning the screw one way or the other.

By making the compound bar longer, or diminishing the diameter of the cylinder around which the thread extends, or both, the sensitiveness of the instrument may be greatly increased.

SIMPLE HYGROSCOPE

No instrument is required to indicate a superabundance of humidity in the air. Everyone knows the discomforts of a moist, hot day in the summer without requiring a hygroscope. Still, to one scientifically inclined it is some satisfaction to know the hygrometric state of the air, and to compare one day with another of the same year or previous years.

A very simple hygroscope which is accurate enough for all practical purposes is illustrated by the engraving. Its construction was suggested by a panel made of two pieces of wood glued crosswise to keep it straight —the very best arrangement of the grain for causing it to assume a concavo-convex form under all conditions of the atmosphere except that in which it was glued together. It has a baseboard 4 inches square and $\frac{7}{8}$ inch thick, with a back piece 4 inches wide and 13 inches high and $\frac{1}{4}$ inch thick, attached to one edge. Near the right-hand edge of the base is secured a block to which is attached a hygroscopic strip made up of a longitudinal piece of any elastic wood (such as whitewood) 12 inches long, 1 inch wide and $\frac{1}{16}$ inch thick,

and a transverse piece of whitewood of the same thickness 1 inch long and 12 inches wide, carefully glued to it, so that the grain of one strip is at right angles to that of the other. These strips of wood should be well



FIG. 204. Hygroscope.

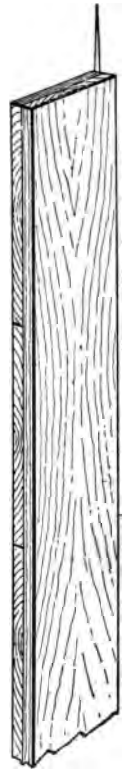


FIG. 205. Hygroscope Strip.

seasoned. This compound strip is secured to the small block on the base of the instrument, and a piece of plain cardboard is attached by two tacks to the wooden back at the center of the board, leaving the ends of the card free. The concave side of the strip should be arranged

to face the left-hand side of the instrument, and a short piece of small wire, say No. 24, or a headless pin should be inserted point outward in the free end of the strip to serve as an index.

The scale is constructed by first placing the instrument under a bell glass with several pieces of wet blotting paper near but not touching the strip. The long, narrow strip does not change its length, but is bent one way or the other by the swelling or shrinking of the piece which is glued crosswise. The hygroscopic strip will straighten out or even curve in the opposite direction when submitted to the influence of moisture, and after the lapse of six or eight hours the glass is removed and a pencil mark is made on the card at the point of the index, which will represent 100 degrees, or the point of saturation. The instrument is allowed to assume the normal position by drying it in the open air, after which it is again placed under the bell glass with a dish of calcium chloride and allowed to remain five or six hours. The calcium chloride removes the moisture and causes the cross-grained side to shrink and thus curve the strip considerably. It now indicates the maximum dryness of the air, and a mark is made at the point of the index, indicating zero. The spaces between zero and saturation should now be divided into ten equal spaces, and each space may be subdivided into ten spaces, each representing one degree.

These lines should be neatly made with a drawing pen. Every tenth graduation should be extended a little and numbered; the entire scale being numbered from 0 to 100, *i. e.*, 0, 10, 20, 30, etc.

This instrument is not intended to accurately show

the exact amount of moisture, as is the case with the more elaborate hygrometers, but to afford a simple means of showing the ever-varying state of the air.

MERCURIAL BAROMETER

The variations of atmospheric pressure are shown by the barometer. The pressure of the air in round numbers is 15 pounds per square inch; that is, a column of air 1 inch square, the height of the atmosphere (which is not positively known), weighs 15 pounds, and will balance a column of water 1 inch square and 34 feet high, or a column of mercury 1 square inch in area and 30 inches high.

A mercurial barometer is here shown on account of facility of construction and the accuracy of its operation. To make the simplest form of mercurial barometer, a strong glass tube a little more than 33 inches long and about $\frac{5}{16}$ inch internal diameter is required. It must be sealed at one end, and left open and contracted to $\frac{1}{8}$ inch at the other. This work is readily done by a glass blower. The open end is fused to remove the sharp edges. A small glass bottle is provided, the body of which is about 1 inch internal diameter and $1\frac{1}{2}$ inches high. The neck is short and a little larger internally than the outside of the tube. A board $\frac{7}{8}$ inch thick, 3 inches wide and 39 inches long has a shallow half-round groove to receive the glass tube, and two brass straps extend over the tube and are clamped to the board by means of screws. Near the bottom of the board a hole is cut for the glass bottle or cistern, as it is called; a small shelf is secured by screws to the back board, even with the lower

side of the hole in the board. A small hole is made in the back board near the top to receive the nail or screw upon which the instrument hangs.

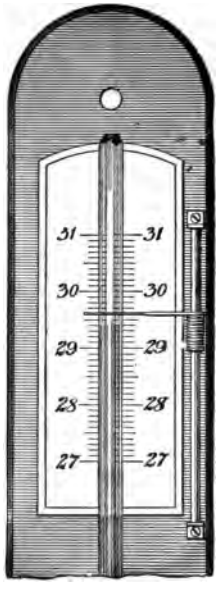


FIG. 206. Scale and Indicator.



FIG. 207. Mercurial Barometer.

Of course all the parts will be tried in place before attempting to fill the tube with mercury.

The tube must be perfectly clean, and only re-distilled mercury should be used. In the bottom of the

glass bottle is placed a layer of pure beeswax $\frac{1}{16}$ inch thick. The wax is made smooth and level by melting it by gently heating the glass bottle over an alcohol or Bunsen gas flame. When the wax is cold the filling of the tube with mercury may be proceeded with. The tube and the mercury are first warmed by passing them over an alcohol or gas flame; then mercury is poured into the tube through a small paper funnel. The tube should be filled to within $\frac{1}{2}$ inch of the end with mercury. Then the clean, dry forefinger is held over the open end of the tube and the tube is placed in a horizontal position and tilted one way and then the other, to allow the bubble of air to gather up as much as possible of the air contained in the tube. The tube is then placed open end up and entirely filled with mercury. It is then inverted while it is kept closed by the finger. The end of the tube is placed below a body of mercury in a suitable vessel and a little of the mercury is let out so as to produce a partial vacuum at the top. Then the tube is closed and again turned into a horizontal position and tilted in one way and then the other, and at the same time turned or rolled over so as to cause the bubble to gather up any air that may remain. The tube is again inverted and filled, until it is entirely full of mercury. The finger is again applied, and a vacuum is produced by allowing a small amount of mercury to escape, when the tube is vertical as before. It is closed and tilted, allowing the bubble to again gather air. This operation is repeated two or three times. The tube is finally inverted and filled with mercury, so as to present a convex surface above the open end of the tube. The glass bottle containing the wax is placed over the

open end of the tube and pressed down, causing the wax to make a good contact with the end of the tube.

The bottle is held firmly in place by the finger, and the bottle and the tube may now be inverted together, and after putting a little mercury in the bottle, the latter may be placed on the shelf prepared for it, and the tube may be raised a little, so as to clear its open end from the wax, and the tube is fastened in place by clamping it with the brass strips and screws. More mercury is added to that in the bottle so as to make the depth about $\frac{3}{4}$ inch above the lower end of the tube. A quantity of clean cotton wool is placed in the mouth of the bottle around the tube to exclude dust, at the same time to admit air freely. The barometer is now finished with the exception of the scale.

A scale of inches $\frac{3}{4}$ inch wide and 4 inches long is laid out in the center of a card $2\frac{1}{2}$ inches wide and $6\frac{1}{2}$ inches long. Each inch is divided into tenths, and the divisional lines for the inches and half inches are extended beyond the $\frac{3}{4}$ inch limit. The beginning of the scale is numbered 27. The upper end of the first inch is numbered 28, the second inch is numbered 29, the third inch 30, and the fourth inch 31. The scale is placed behind the tube and the division line corresponding with the line at the top of the mercury in a standard barometer is placed in the same position relative to the mercury, and fastened by small tacks.

To enable the observer to mark the height of the column of mercury, so that he may compare the present observation with the previous one, an indicator is provided, which consists of a rod supported by posts attached to the board, and a short section of spiral spring placed on the rod, with the upper extremity

straightened and extending over the barometer tube. This end of the wire is flattened by hammering to make a more delicate index.

In a general way the changes of the barometer are given, but they must be taken with some allowance. High winds and storms usually follow the sudden drop of the mercury. The rising of the mercury generally indicates fair weather; the drop of the mercury indicates bad weather. The fall of the mercury in sultry weather is followed by thunder; the rise of the mercury in winter indicates frost. In frosty weather the fall of the mercury precedes a thaw, and the rise is followed by snow. Sudden changes in the barometer indicate similar changes in the weather. Continued foul weather may be expected if the mercury falls slowly; on the contrary if it rises slowly continued fair weather may be looked for. Changeable weather is indicated by an unsettled barometer.

It is perhaps unnecessary to caution the maker of the barometer to conduct the various operations of filling and adjusting above a large platter or piece of smooth paper, with the edges turned up to avoid unnecessary waste of mercury.

PART VI.

TELESCOPES AND MICROSCOPES

HOW TO MAKE A TELESCOPE

NO ONE can look into the starry depths at night without a feeling of wonder and awe, nor is this feeling lessened when the mind grapples the question of space and contemplates the awful abysm that separates us from even the nearest star, to say nothing of the points of light faintly visible to the naked eye, nor of the telescopic stars removed to such distances as to bewilder the mind and baffle the imagination in the attempt to realize their remoteness.

Who does not desire to become more familiar with these distant bodies and to possess all the knowledge that can be obtained by observation? Much can be done by the unaided eyes, and a great deal more can be accomplished by means of a telescope of very moderate proportions and power. An ordinary opera glass is not to be despised, but of course an instrument with a larger objective and a longer focus is much more efficient and desirable.

Our engraving represents the telescope, its standard, and the various parts, in section and in detail. The object glass, A, shown in the engraving, is a meniscus lens 2½ inches in diameter and 36 to 38 inches focus. It is mounted in a wooden cell, B, having an internal flange or fillet about $\frac{1}{16}$ inch wide, forming a true support for the lens and bearing against the end of the paper tube, D, which forms the body of the telescope.

The lens is retained in its cell by a flat strip, E, of brass which is sprung into the cell and is pushed down against the lens. The cell is fastened to the tube by



FIG. 208. A Simple Telescope.

common wood screws, which pass through the colla into the paper forming the tube. It is perhaps needles to say that the cell should be made of some thoroughl

seasoned hard wood, which is not liable to atmospheric influences. Hard maple answers a good purpose, but mahogany is to be preferred.

To protect the objective when not in use a cap, F, of tin or pasteboard neatly covered with morocco or velvet is fitted to the cell.

The paper tube of which the telescope body is formed is such as is commonly used for rolling engravings for mailing. It is 3 inches external diameter and 32 inches long (about 4 inches shorter than the focus of the objective). The exterior of the tube is covered with Java canvas attached by means of bookbinder's paste (flour paste with glue added), and varnished when dry with two or three thin coats of shellac varnish. This gives the tube an elegant and durable finish.

The focusing tube, G, which is of brass, $1\frac{1}{4}$ inches internal diameter, and 12 inches long, is guided by a turned wooden piece, H, fitted to the end of the pasteboard tube, D, and held by three or four ordinary round-headed wood screws.

The piece, H, has a shoulder, *a*, against which the end of the pasteboard tube abuts, and only about three-quarters of an inch of the piece, H, actually fits the tube, the portion from *b* to *c* being tapered as indicated in the engraving, and near the extreme inner end, about $3\frac{1}{2}$ inches from the shoulder, there are three screws, *d*, used in collimating the focusing tube, G.

The bore of the piece, H, is somewhat larger than the focusing tube, G, and is provided with a cloth lining, *e*, at each end to insure the smooth working of the tube.

A short distance from the shoulder, *a*, a mortise about three-quarters of an inch square is made through

the side of the tube, D, and the piece, H, and a transverse slot, *f*, is formed to receive the wooden spindle, I, which is enlarged in the middle to receive the rubber thimble, J, and has on one end a milled head by which it may be turned. The spindle, I, is held in place by concave pieces, *g*, which in turn are retained by the curved plate, *k*, attached to the tube, D, by screws. The rubber thimble, J, must be of sufficient diameter to reach to and press upon the focusing tube, and the latter has a series of transverse grooves filed in it. This will insure sufficient friction to move the tube, G, in and out when the spindle, I, is turned. This simple device replaces the usual focusing mechanism, and is to be preferred to a rack and pinion, unless the latter be perfectly made, and it is certainly superior on the score of cheapness.

The cell, B, piece, H, and spindle, I, should be blacked and polished on the outside, and the cell should be left dead black on the inside. The interior of the tubes should also be dead black. This surface may be secured by adding lampblack to a little very thin shellac varnish, and applying it to the inside of the tube by means of a swab. The focal lengths of the lenses of the astronomical eyepiece should be to each other as three to one; the field lens, which is nearest the object glass, having the greatest diameter and the longest focus, and the convex side of each lens should be turned toward the object glass. Their distance apart should be one-half the sum of their focal lengths. These lenses are mounted in a wooden cell, L, whose exterior is fitted to the focusing tube, G, and grooved circumferentially to receive a strip of cloth, which is glued in, and insures a good fit. The cell is bored in different

diameters to receive the field lens, *h*, the diaphragm, *i*, and the eye lens, *j*, all of which are held in place against the shoulders formed in the cell by circular springs of brass, which are sprung in as in the case of the object glass. The eye aperture should be about ¼ inch, and the aperture of the diaphragm should be about the same.

It is well enough to make the diaphragm adjustable, so that it may be moved back and forth to secure the best position. It will be found, however, that, if placed just beyond the focus of the eye lens, it will give the best results.

A circular recess, *k*, is formed in the face of the eyepiece to receive a sun glass, which is retained in place when in use, by a short curved spring, *l*. The sun glass is simply a disk of very dark glass. It must, in fact, be nearly opaque; some of the glass, known as black glass, answers the purpose very well.

If but one astronomical eyepiece is made, probably the most satisfactory combination would be: Field lens, 1½ inches focal length; eye lens, ½ inch; distance apart, 1 inch. It is advisable, however, to have three eyepieces for different purposes—one of higher power and one of lower power than the one described.

In this connection, I will describe a terrestrial eyepiece, referring to the sectional view, Fig. 209, although it is of little use to adapt such an eyepiece to this instrument unless it is first provided with an achromatic objective. It is then a powerful telescope, which will enable one to see well for many miles. The method of mounting the lenses described in connection with the astronomical eyepieces will be followed here, therefore little more than the diameter and focus of

the lenses and their distance apart need be given. There are four plano-convex lenses, A′, B′, C′, D′, mounted in two pairs in wooden cells, E′, F′, fitted to the tube, G′, which in turn is fitted to the focusing tube, G. The cell, E′, has a $\frac{1}{4}$-inch aperture for the eye and a bead which projects beyond the tube, G′. The lens, A′, is about $\frac{7}{16}$ inch in diameter and 1 inch

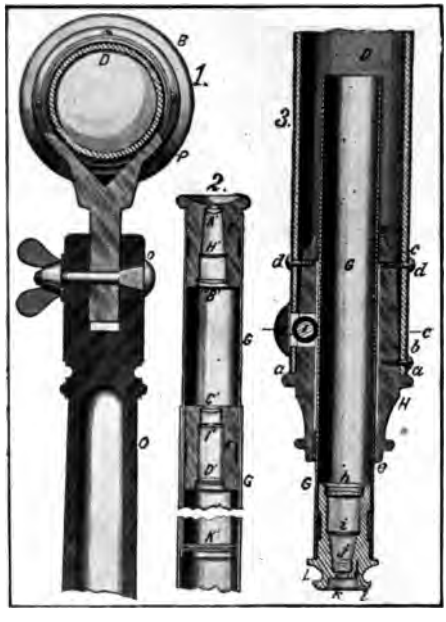


Fig. 209. Details of Telescope and Terrestrial Eyepiece.

focus. The lens, B′, is $\frac{3}{4}$ inch diameter and $1\frac{1}{2}$ inch focus. The lens, C′, is $\frac{7}{16}$ inch diameter, $1\frac{1}{4}$ inch focus. The lens, D′, is $\frac{5}{8}$ inch diameter and $1\frac{1}{4}$ inch focus. The plane face of A′ is $1\frac{3}{4}$ inches from the plane face of B′, and a stop, H′, having a $\frac{7}{16}$ inch aperture, is placed

1¼ inches from the face of the lens, A′. From the plane face of the lens, B′, to the plane side of the lens, C′, it is 3⅜ inches. The distance between the plane side of the lens, C′, and the plane face of the lens, D′, is 1⅞ inches. At a distance of $\frac{7}{16}$ inch from the face of the lens, C′, there is a diaphragm, I′, having a ⅛-inch aperture. It will be observed that the convex sides of the lenses, C′ D, are turned toward each other.

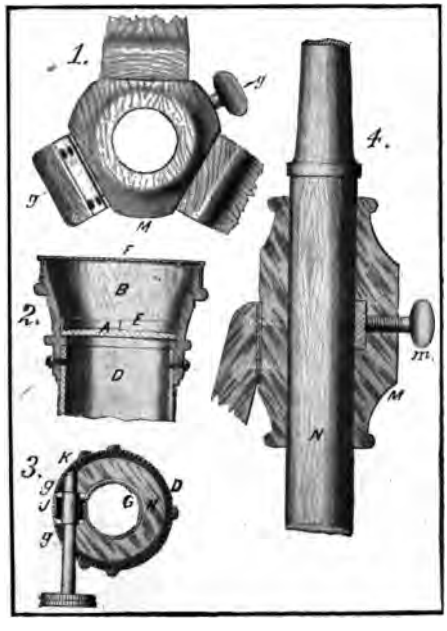


FIG. 210. Details of Telescope.

At the extreme inner end of the tube, G′, there is a diaphragm, K′, of $\frac{5}{16}$ aperture, which is held in place by two circular springs. The interior surfaces must be well blacked to prevent reflection.

I have given cheap yet efficient methods of holding the lenses. If desired the reader may, of course, make the mountings of brass, and fit the instrument up according to his taste and ability.

The arrangement of the various parts is clearly shown in the sectional view, No. 3, Fig. 209, and the focusing device is shown in No. 3, Fig. 210.

In regard to the matter of collimation I have found that by cutting off the ends of the paper tube truly in a lathe, the cell, B, and the piece, H, will be measurably true. To determine whether the focusing tube, G, and cell, B, are axially in line, a truly cut cardboard disk with a pin hole exactly in the center, may be placed in the cell, B. A similar disk may also be placed in each end of the focusing tube, G.

Now, by adjusting the piece, H, by means of the three screws, *d*, the three pin holes in the disks may be readily brought upon the same axial line; then, if the lenses have been carefully centered by the manufacturer, the telescope will be found sufficiently well collimated. If, however, it is desired to ascertain whether the lens is truly centered, it may be turned in its cell, while the telescope is in a fixed position, and directed at some immovable object. If the image moves as the lens is turned, it shows that the work has been carelessly done.

If there are doubts as to whether the axis of the objective coincides with the axis of the tube, the tube may be supported in V-shaped supports adapted to the truly turned ends. Then by placing a candle at some distance from the face of the lens, and turning the tube in its V supports, at the same time viewing the reflection of the candle in the lens, it will at once be

known by the movement of the reflection that the cell requires adjustment to render the axis of the objective and that of the tube coincident.

With a telescope of this description a large number of celestial objects may be examined with great satisfaction. The Moon furnishes an unending source of delight, showing, as it does, a face that is ever changing throughout the lunar month. Jupiter may be coming into good position and affords an interesting study of which one does not soon tire. The telescope described will show the satellites in their varying positions from night to night. It will show the dark band across the face of the planet, and will afford a realizing sense of the magnitude of this great body.

Saturn may be in a good position for observation, and his ring may be clearly seen. The meniscus lens will show a little color, and its definition will be quite defective when directed to such bright objects as the Moon, Jupiter, Saturn, Mars, or Venus with the full aperture, therefore the aperture should be reduced by a diaphragm of cardboard. A little experiment will determine the best sized aperture. For nebulæ, star groups, and double stars, the full aperture should be used. The great nebula of Orion is an interesting object; many of the star groups are very pleasing, the Pleiades for instance. The sun also, when the spots are visible, is a satisfactory object for this instrument. Of course, the sun glass will be applied before the observer attempts to view the Sun, otherwise the eye may be injured or destroyed. It may be that some reader of this article may have a double or plano-convex lens of long focus, which he might desire to press into the service. Either of these may be used, but the

meniscus is better. If a good job is made of the mountings it will not be long before the meniscus, or the plano or double convex lens will be supplanted by a good achromatic objective, which will increase the efficiency of the instrument many fold. Such a lens is not very expensive. It may be procured from almost any optician.

As to the telescope stand little need be said, as its construction is so clearly shown in the engraving. I will say, however, in the beginning, that there is no danger of getting it too solid. If it is very clumsy it is no matter. If it is slender it will be like a "reed shaken by the wind," only "more so," as every tremor has the benefit of the magnifying powers of the telescope and is amplified to a wonderful extent.

There are undoubtedly better stands than the one represented, but it is easily constructed and answers an excellent purpose. From the ground to the top of the hexagonal hub, M, it is four feet. Three of the alternate sides of the hub are wider than the intermediate ones, to receive the wrought iron hinges by which the legs are attached. To attach the hinges, the pin is first driven out; one-half of the hinge is then attached to the leg, and the other half to the hub, M, when the pin is replaced.

No. 1, Fig. 209, is a top view of the hub and the upper portion of the legs. No. 4, Fig. 210, is a vertical section on the line, *g*, *g*, in Fig. 209. A 1¼-inch hole is bored through the hub to receive the standard, N, which supports the telescope and is clamped at any desired height by the thumb screw, *m*. To prevent marring the standard a piece of sole leather is interposed between the screw and standard. An arm, *n*, is hinged to each

of the legs and folds down upon the standard, so as to spring the legs outwardly, and thus render the stand very rigid. The lower ends of the legs terminate in spikes, and a strap is attached to one of the legs to fasten them all together when the instrument is not in use.

The upper end of the standard, N, is reduced in size, and made slightly conical for receiving a socket, O, to the upper end of which is jointed an arm attached to the V-shaped trough, P, in which the telescope is secured by straps. The form of the joint is shown in Fig. 210, which is a vertical transverse section taken through the socket, O, trough, P, and body of the telescope. A strong bolt, *o*, forms the pivot of the joint between the socket, O, and trough, P, and is provided with a wing nut by which it may be tightened. The surfaces of the joint as well as the upper end of the standard should be coated with black lead to insure smooth working. A post set firmly in the ground, while it cannot be moved from place to place, has the advantage of being rigid, and forms one of the best of cheap stands. A fixture screwed in the window casing of a south window, and another attached to a north window, afford solid supports for the instrument, and have the additional advantage of permitting the observer to remain under cover.

THE MICROSCOPE

The man who has passed boyhood without knowing something of what is revealed by the microscope, has missed one of the pleasures of life, and has failed to look into one of the most interesting and profitable studies open to the seeker after knowledge.

Probably the best form of simple microscope for the beginner is a Doublet, of which three forms are shown in the engraving. If this cannot be had, a cloth tester, or a jeweler's eyeglass, will show much which the eye cannot see distinctly. The doublet consists of two plano-convex lenses mounted in a short tube with their convex surfaces facing each other, and separated by a distance equal to one-half the sum of their focal lengths.

The habit of using the lens creates the habit of observation, and this rapidly increases one's fund of general information.

The doublet is convenient and inexpensive. Its power, however, is fixed. If a different power is required another doublet will be needed. Probably three-fourths inch is the most useful focus.

Better for real work is the microscope shown in Fig. 212. It has a glass plate on which to place the object to be examined, and is provided with a mirror to reflect light from below up through transparent or translucent objects. The arm which carries the lens swings so as to bring the lens over any part of the plate and slips readily up or down to bring any part of the object into focus. The lenses are doublets. They may be had of $1\frac{1}{2}$ inch, 1 in., $\frac{1}{2}$ in., and $\frac{1}{4}$ in. focus. Probably the $\frac{3}{4}$ inch and $\frac{1}{4}$ inch will prove the most

serviceable. The wooden base is beveled at either end to form rests for the hands in manipulating the objects and lens.

In a slide under the base is placed a metal plate enameled black on one side and white on the other. This is to be placed on the glass stage when opaque objects are under examination.

This instrument will not take the place of a compound microscope, but it answers very well when only

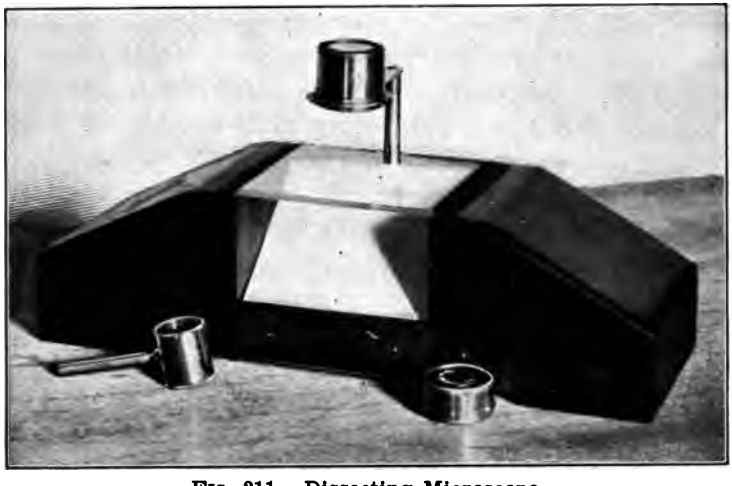


FIG. 211. Dissecting Microscope.

a low power is needed. If the user develops a taste for microscopy and purchases a regular microscope, the dissecting microscope will still be of value to him in the preparation and preliminary examination of objects to be examined by the higher power of the compound microscope, so that the purchase of a dissecting microscope is only introductory to the study of microscopy.

Interesting objects for the dissecting microscope are plant hairs on the back of the leaf of the Deutzia

gracilis, or spiræa, and many other leaves with surfaces rough to the touch. Many of the mints and figworts have hairs wonderfully branched. Pollen, seeds, wings and antennae of butterflies, mosses, spore-cases of ferns, insects, parasites, hairs, feathers, minerals, crystals,—all are interesting and instructive. The formation of crystals on the glass stage is very interesting.

Drop a small quantity of a solution of alum, common salt, sulphate of copper, or other chemical salt, sal ammoniac for example, upon the glass stage and allow it to evaporate while the operation is watched through the lens. For best results spread the drop of solution with the edge of a paper cutter or card into a thin film. A little practice will enable one to make a very uniform film in which the crystals form very beautifully.

Of course the glasses must be perfectly clean. Perfect cleanliness is absolutely essential in every part of microscopic work. Dust especially is the worst foe of the microscopist. It is well nigh impossible to be entirely rid of it, and every mote which remains is magnified by the higher powers into a beam.

A bee furnishes a good object for dissection and preparation. The wings and the sting are especially interesting. The wings are provided with hooks designed to engage a rib on the other half. It is stated that no human being has ever been able to fasten the wings together. The feet and respiratory apparatus are also interesting.

By a little labor one may dissect from a flower or insect interior parts of great interest. Indeed, it is by dissection that most objects are prepared for perma-

nent preservation and use. The tools for this work are few and simple, and although those sold by dealers are to be preferred, yet one may prepare for himself such substitutes as will enable him to do really good

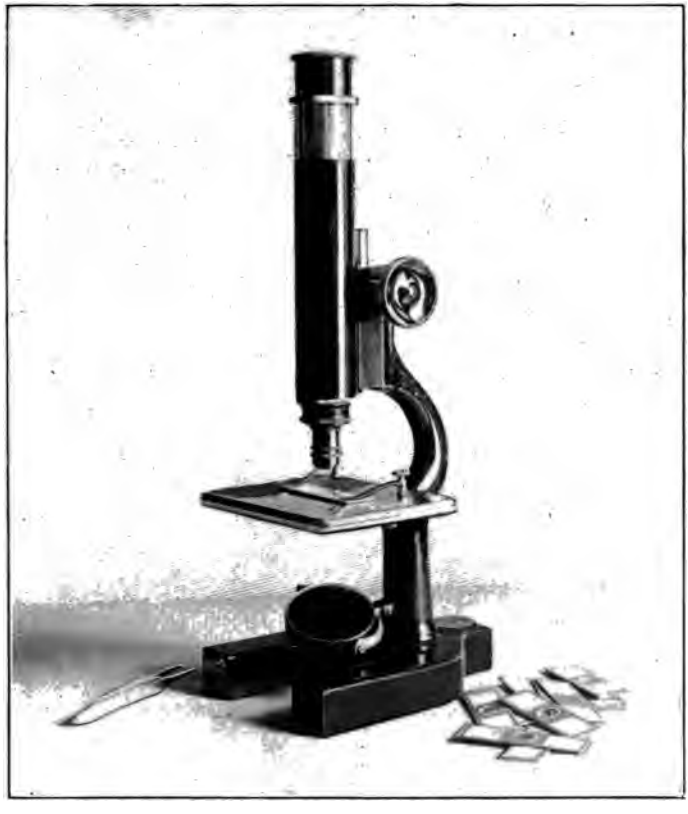


FIG. 212. A Practical Microscope.

work. Our space does not allow much to be said upon this point. The indispensable articles are needles and knives. Dissecting needles are simply sewing needles set in handles. Even a splinter of wood or

wooden penholder answers all purposes of a handle, and the eye end of a needle may be pushed into it so as to be firmly set in its seat. Several sizes of needles should be mounted ready for use. A small pointed blade of a penknife will answer for cutting. A very suitable knife may be made by grinding the end of a needle to an edge and sharpening it on a stone. These tools though simple, are serviceable.

To dissect a flower, for example, place it upon the stage of the microscope and bring into focus with the lens so that it is distinctly visible. At first use the lens of longest focus. Then take a needle in each hand and open the flower, while you look into it. Observe its petals, their colors, markings and hairs, if any are present, its stamens, their shapes and pollen, its seed vessel and any peculiarity. Many an exquisite view into Nature's most beautiful recesses is to be had in this way. So beautiful are many flowers that one feels it to be almost a profanation of a sacred shrine to explore further. But still the unlocking of the shrine may disclose more profound mysteries, so we proceed to cut with one of our tiny knives across the seed vessel which occupies the center of the flower. Notice the symmetry of its arrangement, perhaps in three sections, else in four or five; sometimes as many as ten rows of seeds may be found. It is a very interesting point to study the arrangement and place of attachment of the seeds in the vessel. This mode of working is the mode used by all botanists in their preliminary study of a plant. An entomologist studies an insect in the same way.

After the limit of vision with the long focus lens is reached, a higher power is taken and the search

is continued to the shortest focus the student may have. All of the "coarse anatomy" of an object is studied by means of the dissecting microscope. The compound microscope inverts the view of an object so that a motion to the right seems to be toward the left, and towards, seems to be from one. It is very difficult to become accustomed to this inversion in dissecting, and for that reason the compound microscope is rarely used even by the most expert. Then, too, its field of view is small, and high powers are not needed in dissecting.

The beginner is earnestly advised to study all sorts of minute things which he may find, since discoveries, surprises and most sublime views into the hidden things of Nature await him at every turn. A most useful book for this line of work is "Common Objects for the Microscope," which the student is advised to buy.

But with even the highest skill there is a limit to the use of simple magnifying glasses. The desire to know what lies beyond must be gratified in other ways. A compound microscope is the only instrument which will meet this condition and disclose all that can be seen by lenses. This consists of two lenses, one at each end of a tube, which is in two parts, one sliding within the other. The lens nearest the object is the objective and is really a very fine simple microscope in itself. The upper lens, the eyepiece, increases the magnification of the objective and enables the eye when in the proper position to take in at once the entire picture produced by the instrument, and to study it in detail.

The particular instrument shown in Fig. 211, although very plain and simple, is exceedingly well made, and very useful. It will receive the standard

objectives and eyepieces. It has a very smooth rack motion, which admits of very fine adjustment. The magnification of a compound microscope is varied by using objectives of different focal lengths, eyepieces of different powers, and by changing the length of the tube. This microscope is usually provided with a half inch objective which may be separated to form a one and a half inch objective also, and an inch and a half eyepiece.

If one wishes to put more money into the microscope he will next need a one-half inch eyepiece and a one-fourth inch objective. With these he will have six degrees of magnification at his command, varying from 25 diameters to about 400 diameters. By diameters is meant the number of times broader an object appears. This is the usual mode of stating magnification. The number of times an object is magnified is found by multiplying the diameter by itself. Thus, if a seed is magnified fifty diameters it is made to appear twenty-five hundred times its real size.

A microscope of the value of this one should be handled with extreme care. There are certain simple points to be observed in the use and care of fine glasses. Never touch them with the bare fingers. It greases them and injures their transparency. Wipe them only with a very soft clean cloth, or bit of chamois skin. The glass of which the lenses are made is very soft and easily scratched. The finest dust may be composed of hard grit, which will leave its mark upon the lens if rubbed across it. It is well to blow the dust off before wiping the lens. Lenses are easily broken if dropped. The most common accident is the dropping of the objective while screwing it into its place or re-

moving it. Even with care this sometimes happens. There is but one way of screwing or unscrewing the lens from the tube which is certain to prevent accident. Take the lens between the first and second fingers of the left hand, just as one would a cork or a lead pencil. Now hold it in the position to be screwed into the tube and turn it in wholly by the right hand. Proceed in the same manner in unscrewing the lens. No accident can happen.

With this microscope fitted with the half inch separable objective and the one and a half inch eyepiece an exhaustless field of study and delight is opened to its possessor.

PART VII.

ELECTRICITY

A PRACTICAL PRIMARY BATTERY

EVERY amateur who delights in "making things" dabbles more or less with electricity. Most of these are so situated that they have no access to the large sources of supply of the electric current, such as lighting stations can furnish, and if they would do any real work must make their own generators and apparatus. It is to the assistance of such that the present section is devoted.

The battery, represented by Fig. 213, can be made at a minimum cost, and when made will give a maximum of output. The materials to be purchased are glass jars, porous cups, carbons, zincs, burrs, screws, binding posts and some sheet copper.

All the pieces for the cell come ready for use, except the carbons, which are peculiar to the special form of cell. As the cut shows, there is a ring of carbons to be placed in the glass jar and to fit in the jar as closely as may be without exerting pressure upon the jar. Six plates of carbon are required for each ring. Each plate has two holes of a size to fit the screws. The holes may be made most easily by awls and reamers, such as are to be found in a set of tools in an awl handle. A little patience and experience will enable any one to make the holes neatly. Carbon is very hard and will wear a drill very fast. Hence, it is better not to attempt drilling holes in a carbon plate. Of course the holes should be equally spaced, if the appearance of the finished work is to be considered.

The copper should be about 1-32d of an inch in thickness and about $\frac{3}{4}$ inch wide. It can be bought of this width, or cut by the dealer or by a smith with large shears. A strip must be bent into a six-sided ring of such size that when the carbons are fastened to it the whole will slide snugly into the glass jar. It will be better after one strip has been fitted to its place to straighten it out and use it as a pattern, or template,

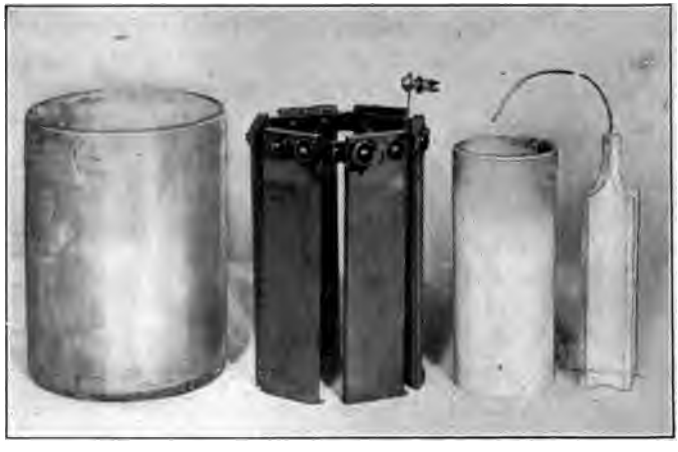


FIG. 213. A Practical Primary Battery.

by which to drill the holes in the rest of the copper strips. They will then be all alike and interchangeable. A template should also be used for making the holes in the carbons, though all holes may be reamed a little on one side or the other to allow the screw to pass through. If the worker has no means of tapping a thread for the screw, he should buy nuts for the screws also. The holes in the copper strips may be punched with a nail punch, if one has no means of drilling them.

For punching holes in this way the end of a stick of hard wood should be used as a bed to rest the copper upon when punched. The strip of copper which leads up out to the binding post may be riveted to the ring, or one end of the ring may be left long enough to bend up a couple of inches above the top of the jar. The carbons should be long enough to reach above the jar so that the metal parts shall not touch the glass. In this battery the fluid employed will corrode metals very rapidly. To prevent the fluid from creeping up through the pores of the carbon and reaching the copper, the ends of the carbons should be dipped in hot melted paraffine and saturated by it before clamping them to the copper ring.

The binding posts may be of any available form except those with wood screws. A machine screw is necessary because the binding post is to be clamped to the copper strip by it. When these parts are screwed together the battery is ready to be assembled.

Nothing has been said about the sizes of jars and the rest, since the cell may be made of a size to fit any jar into which the porous cup and carbons will go. Round porous cups may be had from 1¼ inches up to 5 inches in outside diameter, and round glass jars may be had from 2½ inches up to 7 inches in inside diameter. There is thus ample range of size for any one to consult both the depth of his pocketbook and the quantity of current which he wishes the battery to give. This is a point not understood by many amateurs. The voltage which a cell gives is determined by the kind of chemicals used in it and not by the quantities of chemicals consumed. The current in amperes, which, the voltage being fixed, the cell will give, and the work it can therefore do, are

determined by the quantity of chemicals consumed by the cell in its action. It may be stated as a fair average result that one pound of zinc will give 320 ampere hours in a cell such as this.

Carbon plates can be had in a great variety of sizes and shapes. The best way is for the one contemplating making the battery to write to a dealer in electrical supplies and ask for a catalogue, which he will be glad to furnish. All the parts can then be selected of proper proportion to each other, so that they will go together. Either the Daniell, bottle or Fuller zinc should be used. The cut shows the Daniell zinc. It is a good form because of the large surface exposed to the action of the fluid.

The best solution for this cell is the chromic acid fluid. It should be made by weight, taking chromic acid 18 parts, water 60 parts, sulphuric acid, concentrated, 9 parts. A pint of water may be taken as a pound, and a pint of the sulphuric acid as 1.8 pounds. The chromic acid is a solid and can be most easily weighed directly. Put the chromic acid into the water. It dissolves readily. Then pour the sulphuric acid into the mixture very slowly, a little at a time, stirring it in thoroughly, else a disagreeable accident may be had from the heat produced. It is considered by many that this solution is improved by adding 1 part of chlorate of potash. When it is cold it is ready for use.

The zinc in all cells of this character must be amalgamated; that is, coated with mercury. This may be done directly by dipping the zinc into the solution for a short time and then rubbing mercury upon it, or, better, by putting an ounce of mercury into the bottom of each porous cup. Another way is to add to the solu-

tion in each porous cup, as much bisulphate of mercury as will lie on a quarter of a dollar. The zincs will then be amalgamated directly from the solution.

The cell may be set up in various ways with only slight differences in the resulting current, durability and constancy of action. We will give four modes of arranging the cells:

First—Fill the glass jar to within an inch of the top and the porous cup to the same level with the solution described above.

Second—Fill the porous cup with a mixture of water 10 parts and sulphuric acid 1 part, and the glass jar with the chromic acid mixture given above.

Third—Fill the glass jar with the chromic acid solution and the porous cup with water to which table salt has been added at the rate of 4 oz. to the pint. Sulphate of zinc may be used in place of salt, 6 oz. to the pint.

Four—Fill the glass jar with chromic acid solution and the porous cup with clear water. This will start slower than any of the other modes of filling, but will work, because enough of the chromic acid solution passes through the pores of the cup to act upon the zinc.

The adaptedness of this cell for many uses is shown by the fact that it can be arranged as a one fluid cell also. Removing the porous cup hang the zinc in the center of the glass jar by means of a board cover of the jar through which a hole is made to receive the end of the zinc. The fluid used will be the chromic acid solution. The zinc must be fully amalgamated before putting it into service, and the bisulphate of mercury should be used to maintain the zinc in condition. In

this form the cell gives its strongest current, but will only last about half as long.

Whenever this cell is to be out of use the zinc should be removed from the liquid. The porous cup should be taken out and set in a dish of the same solution as it contains. In this way all waste of the chemicals is prevented.

The battery, as described, is one of the strongest and most reliable primary batteries. With its strongest current it readily heats fine iron and platinum wires. With the porous cup it is adapted to drive motors, fans, and excite electromagnets. A large battery will light small incandescent lamps. Eight or ten cells, holding two quarts each, will drive the motor of *Scientific American Supplement*, No. 641, to full power, and run a sewing machine or turn a small lathe, or do any other equal work. The expense of maintenance is not great. The liquid when it becomes green is exhausted and must be replaced by fresh solution. The zincs can be used till they are entirely dissolved. This battery is not a toy, but a serviceable piece of working apparatus.

ELECTRIC LIGHTING FOR AMATEURS

It is now possible for any one to procure small incandescent lamps from the Edison Lamp Co. and from most dealers in electrical goods. These little lamps can be operated quite successfully by means of easily constructed batteries. It is, of course, a little troublesome, and the expense of the electric light produced in this way is somewhat greater than other lights, but amateurs can derive a great deal of satisfaction from these experiments in electric lighting.

The battery may be made at home, from materials

that may be purchased from the manufacturers of the lamps or from any dealer in electrical supplies. Each cell of battery consists of two plates of carbon 2 in. wide, 4½ in. long, and ⅛ in. thick, one zinc plate 2 in. wide, 4 in. long, and ⅛ in. thick, two strips of wood ½ in. wide, ¼ in. thick, and 4 in. long, two strong rubber bands, and an ordinary tumbler.

The zinc is amalgamated by dipping it in dilute sul-

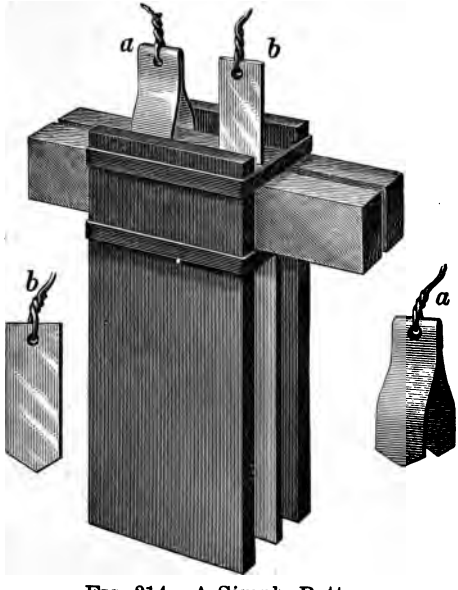


FIG. 214. A Simple Battery.

phuric acid (acid one part, water twelve parts), then sprinkling on a few small drops of mercury, rubbing it about with a swab formed of a piece of cotton cloth tied around the end of a stick. Every portion of the surface of the zinc should be covered with mercury. If the amalgamation is perfect, it need not be repeated.

The carbon plates before use should each be heated

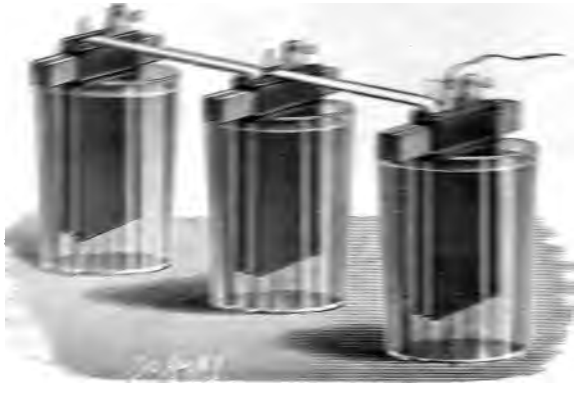


Fig. 213. A Portable Battery.

The zinc plate is placed between the two wooden strips. The carbon plates are placed outside of the strips and held by the two rubber bands, as shown in Fig. 214.

The connection between the carbon plates and the wire leading away from the carbon pole is made by a doubled strip, a, of copper, the ends of which are inserted between the wooden strips and the carbon plates. In a similar way a copper strip, b, is inserted between

e zinc plate and one of the wooden strips. The mbler forming the battery jar should be deep enough allow the wooden strips to rest upon its rim, so as support the plates a short distance from the bottom the tumbler.

The ordinary bichromate of potash solution is used the battery. It is prepared by making a saturated

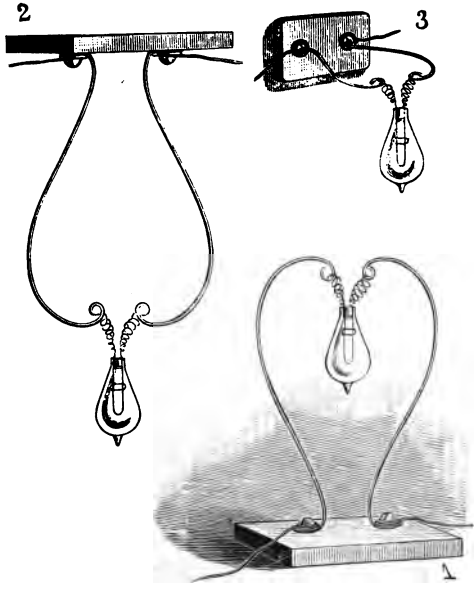


FIG. 216. A Convenient Bracket.

lution of common bichromate of potash in warm ater; then, after cooling, adding very slowly a quanty of common sulphuric acid, equal to about one-fifth the bulk of the bichromate solution. It is advisable add to the solution a very small quantity of bisulhate of mercury, say one-eighth ounce to the quart of lution, to maintain the amalgamation of the zinc

The salts known as the C. & C. battery compound are excellent and very convenient for use in batteries of this class. It is only necessary to dissolve this compound in water to form the exciting solution.

This material is sold in tin cans containing two or three pounds. It absorbs moisture rapidly, so that when it is to be used in small quantities it should be transferred to a stoppered glass jar.

It is, perhaps, needless to say that great care should

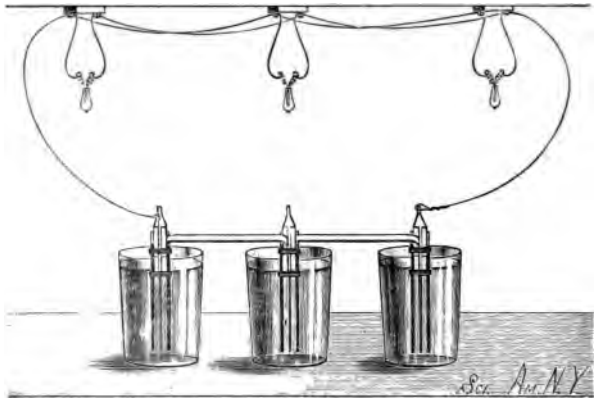


FIG. 217. A Series of Connected Lamps.

be exercised in handling the solution, as it is poisonous and destructive to clothing, carpets, etc. The same remark applies to the battery compound.

One cell of this battery should be allowed for each candle power of the lamp. The zinc of one cell should be connected with the carbon of the next, Fig. 215. The battery may be arranged as a plunger. Directions for making a battery of this kind were given on page 116, of volume 57, of the *Scientific American*.

In Fig. 216 is shown a convenient bracket for supporting small electric lamps. It consists of two curved wires attached to a small piece of board by means of screws, which also serve as binding screws for attaching the wires. The lamp is suspended from eyes formed in the ends of the wires. This device may be used as a standard, as shown at 1, as a hanger, as shown at 2, or as a bracket, as at 3.

In Fig. 217 is shown a series of three small lamps connected with three cells of battery.

The lamps in this case are connected in parallel or multiple are, *i. e.*, one binding screw of each lamp is connected with one wire from the battery. The other binding screws of the lamps are all connected with the remaining pole of the battery.

Copper wire, No. 18 or larger, should be used for making the connections. The battery will run continuously with a single charge of the solution for about three hours. Should the solution become warm and give off hydrogen, the zinc should be reamalgamated at the points where it is violently attacked.

THE ELECTRIC CHIME.

To secure practice in mechanics or in electrical work, the amateur may as well construct something for actual use. A very useful and pleasing electro-mechanical device is an electric chime to be used as a door bell or call bell, or in connection with a clock. It serves its purpose as a call and gives an ever-changing series of harmonic notes.

The first step toward the construction of this device is to purchase the toy known as the tubophone, and

select three of the tubes which produce a chord, or if the maker prefers it, he may buy a piece of mandrel drawn brass tubing, $\frac{5}{8}$ inch external diameter, with walls $\frac{1}{32}$ inch thick, and cut off three pieces respectively $7\frac{5}{8}$, $8\frac{3}{8}$, and $9\frac{3}{8}$ inches in length; each of these should be laid upon two short pieces of soft woolen cord, with

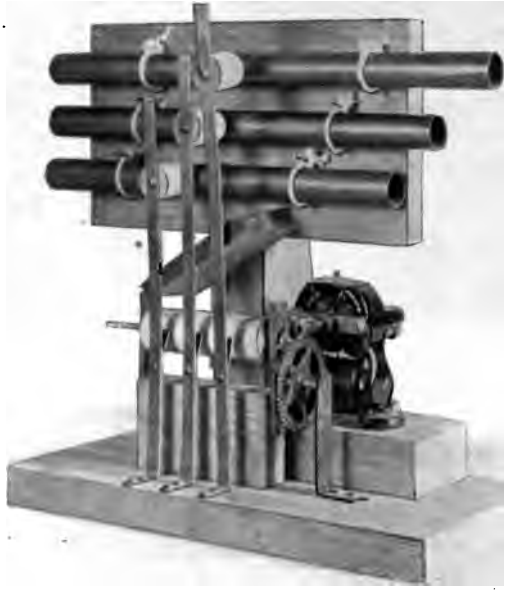


FIG. 218. Electric Chime.

the cord touching at nodal points, that is, at exactly one quarter of the length from the end. Arranged in this way the tubes give out a clear note when struck with a small wooden mallet. By comparing these notes with those of a piano or other musical instrument, the tubes may be tuned. The pitch is raised by shortening

the tube, but as there is no practical way of lowering the pitch after the tube has once been shortened, it would be advisable to cut the tubes a little longer than the measurements given. A baseboard having a short standard is provided, and to the upper portion of the standard is secured a board into which are driven three pairs of wire nails, the nails in each pair corresponding in position with the nodes of one of the tubes. The tubes are suspended from these nails by soft cords passing around the tubes at the nodes or points of no vibration, leaving the tubes free to vibrate at the center and at the ends.

Now it remains to construct the electro-mechanical device for striking the tubes. To the baseboard are secured the angled ends of three strips of spring brass, $\frac{7}{32}$ inch wide and $\frac{1}{32}$ inch thick, which extend above the tubes and carry small wooden mallets in position to strike the middle portion of each tube. The mallets are secured to the springs by means of ordinary wood screws passing through the springs into the mallets.

Behind the springs, at or near their mid-length, is placed a diagonal strip of wood, having secured to its outer edge a strip of felt or chamois skin. The spring strikes this piece and allows the mallet to strike the tube and spring back without jarring. Behind the springs is supported a small shaft on which is placed a wooden cylinder about 1 inch in diameter and $2\frac{1}{2}$ inches long. In the cylinder and opposite the springs are inserted wire nails, arranged to strike short inclined strips riveted to the springs. The nails are placed so that they will strike the inclined strips in different orders; for example: 1, 2, 3; 3, 2, 1; 2, 3, 1; 1, 3, 2.

A toy electric motor having a three-pole armature is used for turning the cylinder, and two clock wheels and a pinion are employed for reducing the speed. A worm is placed on the armature shaft of the motor, which engages the first of the clock wheels. This worm may be cut in a lathe, but if this is inconvenient, a wire may be wound spirally around the armature shaft and soldered. It will, of course, be necessary to wind the spiral so that it will fit the teeth of the clock wheel, and the surplus solder should be scraped from the wire to diminish friction. The motor is provided with binding posts to receive the battery wires. One or two cells of dry battery will run the chime. The chime is used in place of an ordinary call or door bell, or it may be used in connection with a clock, as shown, for making calls at certain hours.

The push button shown in the sectional view is made to close the circuit when the chime is used in place of a call bell or door bell. The button is readily made by boring a small block, *A*, of hard wood in two diameters to receive the head and back of the pearl collar button, *B*, the back of which is held in place by the apertured piece of veneering secured to the face of the block by small screws, while the head of the button rests on a curved brass spring, *C*, secured in a slot in the back of the block, *A*, by a screw. The outer end of the spring projects beyond the side of the block to receive one of the circuit wires. This slot is filled below the spring with insulating material, and a brass plate, *D*, is secured to the back of the block, *A*, and has upon one edge an apertured ear for receiving the other circuit wire. The plate, *D*, is secured to the back of the block by small screws. The free end of the spring, *C*, is

curved over to a point near the brass plate, *D*, so that when the spring is depressed by pressing the button. *B*, it will touch the plate and close the circuit.

The annexed diagram shows an appliance which enables the chime to be used in connection with a clock.

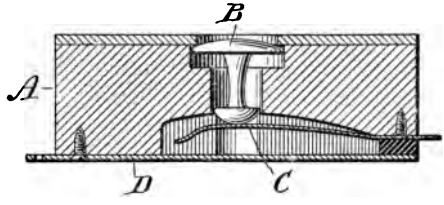


FIG. 220. Push Button.

In front of the dial of an ordinary clock are secured the rings, *A*, *B*, made of $\frac{1}{16}$ inch square brass wire. The supports are of insulating material, and the rings are concentric with the arbor carrying the hands. The hands are bent outwardly to permit of extending over the rings without touching them, and to insure the hands against electrical contact with the rings a thin short sleeve of paper is slipped over each hand near the free end. Each ring has several small radial holes bored in it to receive the brass nails, the heads of which project sufficiently beyond the front surface of the rings to enable the hands to touch them as they pass.

The circuit wires connecting the battery and the chime are connected one with the outer ring, *A*, the other with one of the springs of the cut-out switch shown in the opening formed by the breaking away of the dial. The other spring is connected with the inner ring, *B*. The springs are insulated from each other.

On the sleeve which carries the hour hand is mounted the crossed slotted cam, *C*, also shown detached in the

larger figure. In the slot of this cam is a boat-shaped follower, which slides easily in the slot and is longer than the width of the slot, so that it can, in following

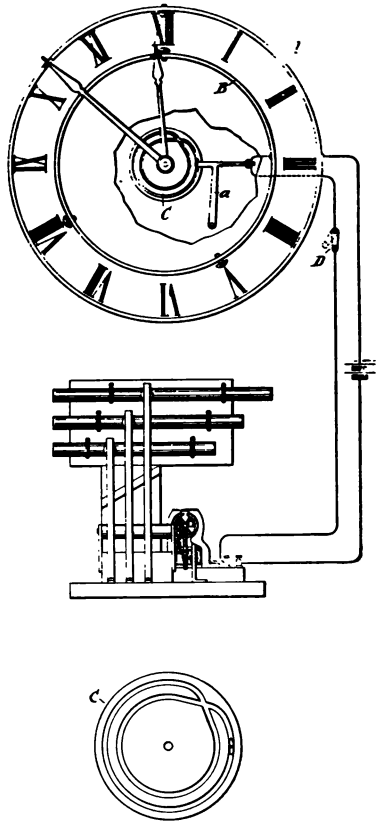


FIG. 219. Chime with Clock connection.

the slot, take the inner and outer portions of the slot in alternation. The follower is pivoted to the angled lever, *a*, which is pushed by the cam between the parallel springs and withdrawn from them in alternation

once in 12 hours. The object of this arrangement is to cut out the chime at night and put it in circuit in the daytime. The cam, *C*, and the angled lever, *a*, are insulated from the clock movement.

A switch, *D*, is provided for throwing the device out of action at any time.

It will be seen that the hour hand must come into contact with the nail on the inner circle and the minute hand must touch the nail in the outer circle to complete the circuit, and cause the chime to sound. The duration of the chiming is limited by the time the minute hand is in contact with the nail. The clock when arranged as here shown sets off the chime at 8 o'clock, 12 o'clock and 5 o'clock. It is now about to ring the chime for 12 o'clock.

HOME-MADE ELECTRIC NIGHT LAMP

A very simple device, which will produce a temporary light of one-half of one candle-power, is shown in the illustration. It will be found convenient for observing the time at night, or for momentarily lighting a closet or an area where the light of a candle or an oil lamp would be objectionable.

The miniature electric lamp, and the dry batteries used for lighting it, can be purchased almost anywhere, and the labor of putting these things together, with a switch and suitable connections, is very slight indeed. A one-half candle lamp requiring 1.58 amperes at 2.5 volts is the first requisite; then two cells of dry battery, giving a current with a pressure of about 3 volts will be needed, and last of all a small packing box, that will just receive the batteries, should be selected. If a

lamp of higher voltage is chosen, more cells of battery will be needed. A 4-volt lamp will require three cells of battery. A little more light will be secured with this

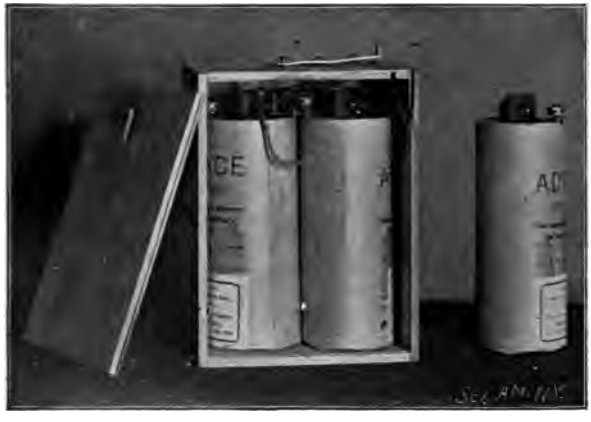


FIG. 221. Battery Box, cover removed.



FIG. 222. Temporary Light.

combination, but it is not desirable to increase the number of cells beyond this, as the apparatus becomes at once too bulky and too expensive. The best combina-

tion is the one-half candle lamp wih two cells of battery. After the lamp is procured it should be tested momentarily by means of two cells of dry battery, connected in series. If the lamp is properly lighted, a packing box which receives the batteries easily is se-

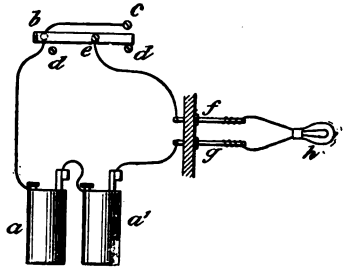


FIG. 223. Diagram of Circuit.

lected, and two small brass hooks, *f g*, are straightened and screwed into the box near the top. Small copper wires are placed in electric contact with the hooks, *f g*, as shown in the diagram. At the top of the box is placed a switch, consisting of a piece of spring brass 3 inches long and ½ inch wide held in place by a pivotal screw, *e*, passing through a central hole in the spring into the box.

In one of the views the lamp is represented as being supported by a hollow wooden column in front of a clock. In this case one of the lamp wires is incased in a very small rubber tube, to insure insulation; otherwise the construction is similar to that described.

Two cells of dry battery will light the lamp occasionally for a long time, if used only an instant each time; but if the lamp is used continuously, it runs the battery down, so that it will require frequent renewal.

The wire from the brass hook, *f*, is placed in electrical

contact with this screw, *e*, and two brass screws, *b c*, are inserted in the top of the box, to serve as contact points for the switch. These screws are connected together and with the zinc pole of the cell, *a'*, by a wire. The carbon pole of the cell is connected electrically with the hook, *g*. The hooks are curved downwardly and the terminals of the lamp, *n*, are wound three or four times around the ends of the hooks, *f g*, respectively, so as to support the lamp above and in front of the face of the watch, hanging upon the hook, projecting from the front of the box.

The longer arm of the switch is turned up to form a thumb piece, and is held normally out of contact with the screw, *b*. By pressing the end of the switch down into contact with the screw, *b*, an electrical contact is formed which lights the lamp. By turning the switch on its pivotal screw, *e*, it is brought into contact with the screw, *c*, thus forming an electrical contact, which is prolonged until the switch is returned to its original position. The movement of the switch is limited by the screws, *d d*.

AN ELECTRICAL CABINET

An electrical cabinet is an assemblage of articles which may be combined in various ways to produce pieces of apparatus. By these a large number of experiments are made accessible to the amateur at comparatively slight expense.

In Fig. 224 sectional drawings of the essential parts are shown, drawn very nearly on a third scale. A are 2 coils, wound with 8 layers of No. 20, single cotton covered magnet wire, both being wound in the same direc-

tion. B, the cores and yoke of an electromagnet, the cores of ⅜ inch soft iron bar. C, the frame for supporting the electromagnet when used as the field coils of a dynamo or motor as in Fig. 237. D, a wooden stand, turned in a lathe, to be used as a support for the com-

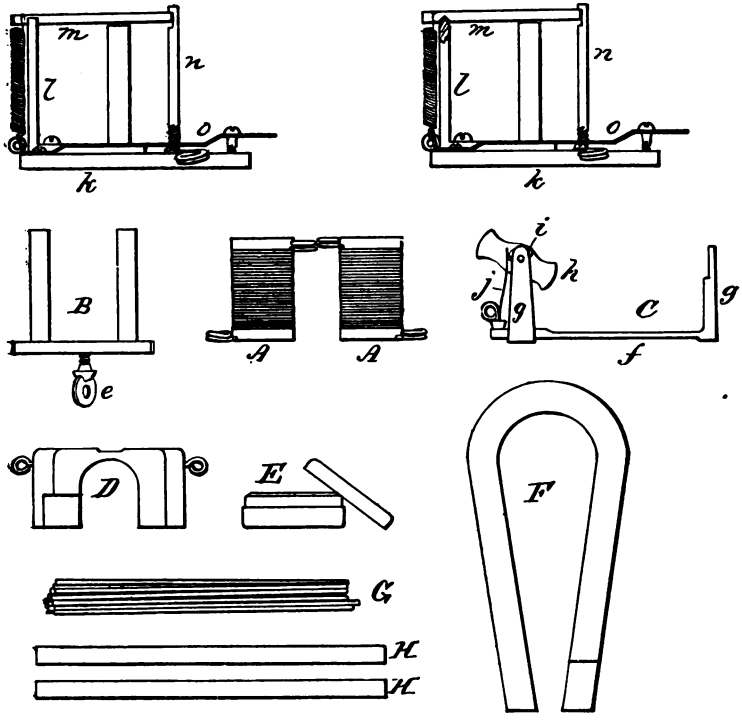


FIG. 224. General View of Parts.

pass E, to form a galvanometer, as in Fig. 229. F, a permanent horse shoe magnet. G, soft iron wires. H, strips of copper. K, frames for telegraph sounders.

By the aid of the Figures for the several experiments the practical amateur will have little difficulty in see-

ing how they are made and put together. The permanent magnet and the compass can be purchased to better advantage. The rest can be made with a lathe and tools. Some No. 28 spring brass wire will be needed for the springs shown on the telegraph sounder

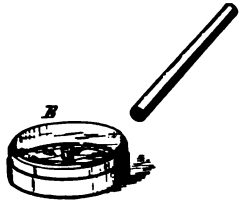


FIG. 225.
Effect of Iron on a Magnet.

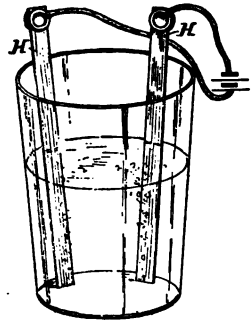


FIG. 226. Decomposition of Water.

at the left, and some No. 18 spring brass wire to be wound into a close spiral a little less than a half inch in diameter, and cut up into pieces of about 3 turns each to be used as connectors in place of binding posts.

In describing the several experiments such additional instruction will be given as the case may seem to require.

The action of iron on a magnet is shown in Fig. 225. Present the end of an iron rod to the compass. The needle is drawn towards the iron and swings till it points directly towards it. The magnet F may be used for this experiment. The north or marked end of the magnet repels the north end of the needle and attracts its south end. As we say, like poles repel, unlike attract. The brass and glass cannot stop the attraction. Paper, wood, anything except iron, may be interposed

between the magnet and the needle without destroying the attraction and repulsion.

The decomposition of water into two gases, oxygen and hydrogen, by electricity is a very interesting experiment. For its best exhibition platinum is required, but as this is a very expensive metal a method is given by which one gas can be produced. Fig. 226 gives the arrangement of the apparatus. The light and heavy parallel lines indicate cells of battery. Two at least are required. A good form of cell is represented in Fig. 229. The glass is a common tumbler. Two plates of battery carbon and one of zinc are clamped together by two bolts which pass through the four strips of wood. Strips of sheet copper or brass, d and e, are included between the strips; d is cut long enough to

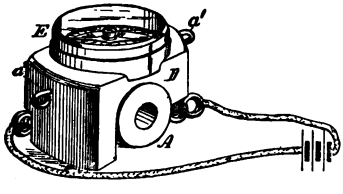


FIG. 227. Galvanometer.

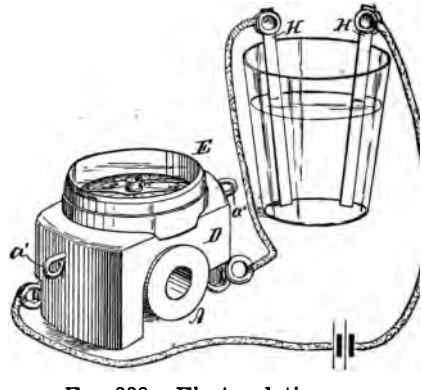


FIG. 228. Electroplating.

connect with both carbon plates. Two of the spirals described above are pushed on these strips to receive the copper wires used in forming the circuits. This sort of connector is nearly as good as a regular binding post and costs a mere trifle.

The fluid for the cells is made by dissolving in cold water as much bichromate of soda as the water will take up, and adding slowly and with constant stirring one-tenth of the volume of sulphuric acid. The plates should only remain in the solution while they are in actual use.

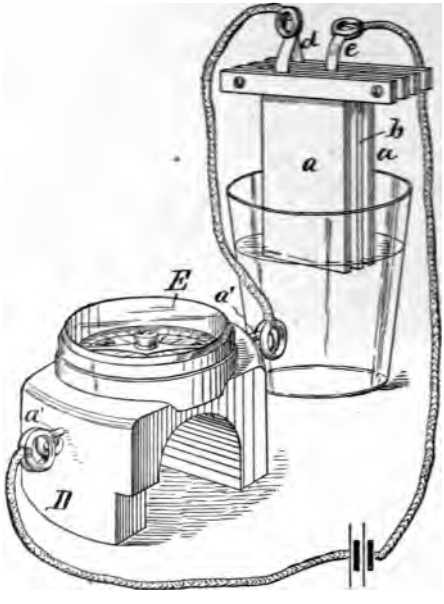


FIG. 229. Detector Galvanometer.

The tumbler shown in Fig. 226 is to be filled with water and a little sulphuric acid added. Lacking the acid, vinegar may be used in its stead.

With two cells fine bubbles of hydrogen gas come off slowly from the copper which is attached to the wire leading from the zinc of the battery and rise to the surface. The oxygen combines with the copper and does not appear as a gas at all. If platinum were used

for the other strip oxygen would be given off from its surface, since oxygen does not combine with platinum under these conditions. This most interesting experiment was first performed by Sir Humphry Davy many years ago.

Fig. 227 shows how to arrange one of the coils A, the compass E, the support D, and the battery as a galvanometer. Place the coil so that its length is east and west and place the compass over the coil. The needle will lie crosswise of the coil. When the current

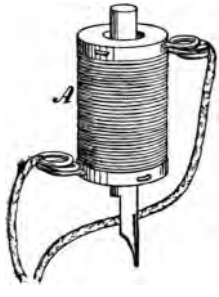


FIG. 230. Sucking Coil.

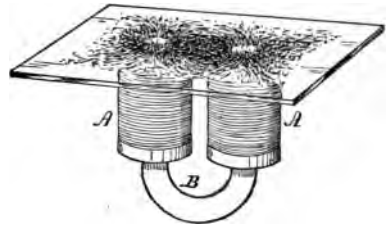


FIG. 231. Lines of Magnetic Force.

flows the needle is turned from its north and south position. The laws and meaning of this is explained fully in the text books of electricity.

Electroplating has become one of the most important industries. It can be performed with the apparatus of Fig. 228. The arrangement is the same as that of Fig. 226, except that the tumbler is now to be filled with a liquid containing the metal with which the article is to be plated. To plate with copper a solution of copper sulphate may be used, though carbonate of copper is better; for nickel a double carbonate of nickel and ammonia is used. The metal will be deposited on the

strip attached to the wire from the zinc, that one on which the hydrogen appeared when water was decomposed. The other strip must be of the metal with which the plating is to be done.

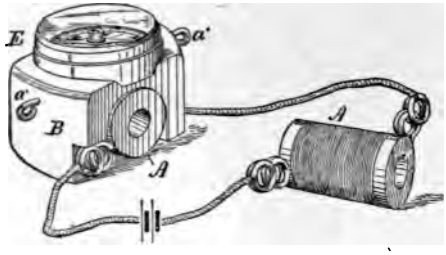


FIG. 232. Mode of Inducing an Electric Current by a Magnet.

More instruction and much experience will be required for real work; but much pleasure can be derived by watching the process in this simple manner. Three or four cells should be used for depositing nickel.

If a copper wire is passed straight through the fixture D, and the parts are set up as in Fig. 229, it will constitute a detector galvanometer, suitable for large currents, as the arrangement in Fig. 27 is adapted for

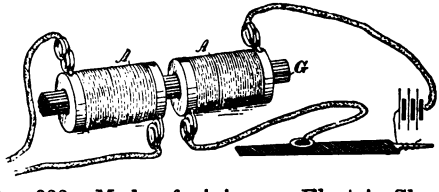


FIG. 233. Mode of giving an Electric Shock.

feeble currents. The wire in all cases must be placed north and south, or lengthwise of the needle when at rest.

The uses for an electromagnet in experimenting are very many. It is the most important piece of electrical

apparatus, and was invented by Sturgeon of England and also by Prof. Joseph Henry in America. Probably neither knew the work of the other. Henry's invention led directly to the electric telegraph. Fig. 230 is given as an illustration of the power of a helix to draw iron or steel into itself. If a strong battery is used the pen is sucked into the coil with considerable force. A large number of small wire nails may also be held up in the coil without visible support. It is wizard-

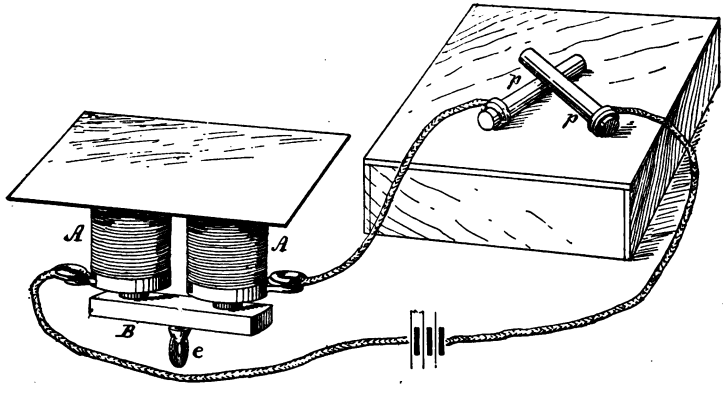


FIG. 234. Microphone.

like to see a piece of heavy metal hanging in the air upon nothing. Numerous modifications of this curious experiment will suggest themselves to an ingenious person.

With the two coils A, put upon a U-shaped iron rod $\frac{3}{8}$ inch thick, as in Fig. 231, the beautiful magnetic phantom or magnetic field of force can be made visible. The wires from the spools are connected to the battery, which is not shown. Join the two spools together so that the outside of the winding of one is

connected to the inside of the winding of the other. A thin board is laid over the poles and iron filings sifted over the board. Then tap the board gently with the tip of a finger. The filings jump with sudden alacrity into lines, definite and exact. The figure shows these lines. It means magnetic attraction. Now change the connections. Join the two outside wires of the spools to the battery and the inside wires to each other. The figure changes to one exhibiting repulsion. The lines shun each other.

If blue print paper be pinned on the board and the whole exposed in the sunlight, fine photographs may

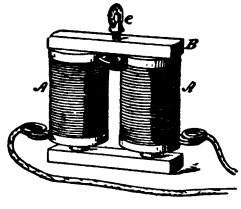


FIG. 235. Electromagnet for Lifting.

be made of these beautiful figures. By using horse shoe and bar magnets, endwise and flatwise, a great variety of magnetic fields may be mapped.

Next arrange the apparatus as in Fig. 232. The compass needle is strongly deflected from its north and south position. Now remove the battery and close the circuit. Plunge a bar magnet into the right hand coil. The needle swings, though not so strongly as before. An electric current is generated so long as the magnet is in motion, either in or out of the coil.

If the cores of the coils in Fig. 232 are filled with iron wires a current may be generated by simply tak-

ing the right hand coil in the hands, holding it north and south and turning it over quickly. These effects were discovered by Ampere, for whom the unit of current is named. The student should look up the subject in text books of electricity.

The giving of electric shocks to one's friends is always a pleasant pastime. One mode of doing this is illustrated in Fig. 233. Of course no severe shock can be given in this way. The metal handles of Fig. 238 should be connected to the open ends of the wires to

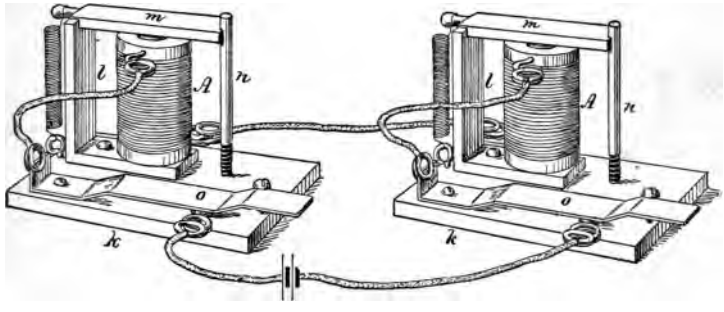


FIG. 236. Electric Telegraph.

the left. Scrape the ring along the file and a slight shock will be felt by one who grasps the handles with moist hands. The shock is produced by an induced current. The arrangement is a very simple form of induction coil. As the making of a strong coil is a difficult matter, a special and full description of the coil to be made should be obtained before undertaking such a piece of work.

Fig. 234 is a microphone. Two bits of iron wire, or bright wire nails, p, are connected to the wires and laid

on the top of a box made of thin wood as shown. Pine is to be preferred. A sheet of iron is laid upon the top of the electromagnet. On tapping the box gently a much louder sound will be heard from the sheet of iron, when all is working well. This effect is the basis

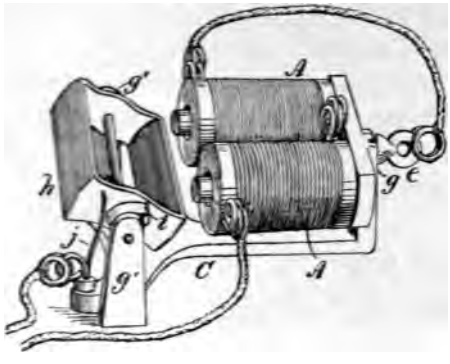


FIG. 237. Dynamo or Motor.

of the invention of the transmitter of the telephone. If a telephone receiver is used in place of the electromagnet and sheet of iron, the feeblest sounds produced on the top of the box are greatly intensified. The microphone box may even be used as a telephone transmitter if the wires are long enough to permit it to be placed in another room, and all the parts are sufficiently delicate.

The arrangement of an electromagnet for lifting purposes is shown in Fig. 235. By means of a spring balance one may find the pull necessary to remove the armature when the number of cells of the battery is varied from one cell up to its full capacity. The iron bar used as an armature should always be as large in cross section as the iron core of the magnet.

Fig. 236 will guide one in setting up a telegraph line, with a station at each end. The key is simply a strip of spring sheet brass. When not in use it is pressed down and caught under the head of the screw beyond it so as to close the circuit. The construction of the sounder is so simple that it will not be given in detail. The most difficult part to adjust is the vibrating arm, m, whose blows against the slot in the post to the right produce the sound which gives the name to the instrument. The vibrating bar should not strike the electromagnet when it is pulled down, nor have a very wide range of motion. The bar must either be wholly of iron, or better, have a block of iron riveted to it, since brass is not attracted by a magnet. The tension of the fine wire spring on the left determines the force necessary to pull the bar down.

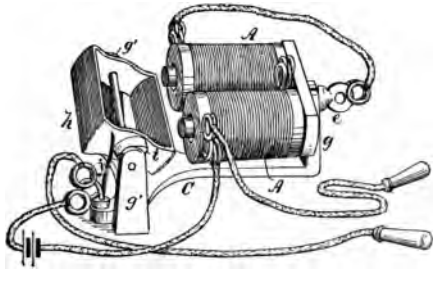


FIG. 238. Shocks by Rotating Coil.

To work the telegraph swing the key from under the head of the screw which holds it down. This opens the circuit. The bar of the sounder flies up. Now, press the key down till it touches the wires below it. The current from the battery flows and the armature is jerked down, giving a sharp blow on the post which detains it. As the key is moved down and up the arma-

ture moves down and up, producing the clicks which all have heard in a telegraph office.

By getting a Morse alphabet and mastering the art of producing dots and dashes two persons may soon learn to send messages to each other.

A model of a dynamo may be built from the parts, A, B and C, of the cabinet. This is shown in Fig. 237. The electro-magnet formed by A and B is fixed upon C, and the circuit completed by short pieces of magnet wire. The open ends to the left may be connected to the galvanometer, D and E, to detect the current.

The rotating coil, H, and the commutator J, are somewhat difficult of construction. The coil consists of about 100 turns of No. 20 single cotton-covered magnet wire. The inner end of the wire is soldered to one of the half rings of the commutator, the outer end to the other half ring.

On whirling the coil rapidly a feeble current will be produced. The current will be reversed, if the coil is whirled in the opposite direction.

This tiny dynamo may be transformed into a series wound motor by connecting the battery in place of the galvanometer.

By changing the connections as shown in Fig. 238, the electric current may be felt in the handles when the armature is whirled rapidly.

Though the experiments described by no means exhaust the subject, nor the resources of the electrical cabinet, still they place before the studious amateur enough to employ many an hour most profitably, and to incite him to further study and to higher work.

SIMPLE ELECTRIC MOTOR

Almost every young amateur mechanic is desirous of making something having the ability to move and show action. An electric motor does this; and while the mechanic is making a good piece of machinery, he is also learning the principles of electricity.

The motor we shall describe is intended to turn a fan or light machinery by means of a current derived from a battery. It will drive a light sewing machine or other machinery requiring a similar amount of power, and it is so simple as to admit of being constructed with the tools ordinarily possessed by an amateur.

To begin a motor at the right point is very important. The first thing to be done is to construct the armature—the part which revolves. On account of its simplicity, we have selected the Gramme armature.

The core of this armature consists of a ring formed of No. 24 sheet iron. A strip $\frac{3}{4}$ inch wide and 8 feet long (the length of a sheet) is carefully cut from the sheet and wound upon a cylindrical piece of wood in the lathe or by hand. The wood cylinder is $1\frac{3}{4}$ inches in diameter and 1 inch thick, and in the edge is cut a shallow notch of a depth equal to the thickness of the sheet iron, as shown in Fig. 240. In the iron, $\frac{1}{8}$ inch from the end is drilled a hole, countersunk to receive a wood screw, which passes through the sheet iron into the wood, and fastens the end in the notch in the wood. The sheet iron thus attached to the wood may be wound closely around the wooden mandrel without a kink being formed by the inner end of the strip, which is in the notch.

Before beginning the winding, a piece of strong an-

bared wire, stove-pipe wire for example, is placed in a handy position, and when nine layers of the iron have been wound the strip is cut off and the binding wire is wrapped around the coil and twisted together at the ends, to keep the sheet iron from unwinding.



Fig. 239. Electric Motor.

The wood and the coiled sheet iron are together removed from the lathe (or vise if it is being done by hand), and placed in a fire, which will heat the iron to a cherry red and burn out the wood. The ring is

then covered with ashes and allowed to cool slowly. This anneals the iron, and improves its magnetic permeability.

After removal from the ashes, and while the binding wire is still in place, the ends are secured by passing rivets through them; the inner end, which was bent, is cut off, and the ends are beveled with a file, and all the sharp corners are reduced by the same means.

The core of the armature is then covered with adhesive tape (either electrical or bicycle tire tape), when it is ready to receive the magnet wire with which it is to be wound. The ring is divided into five equal sections, and marked with a pencil to show how much space each coil of the armature is to occupy. There are five coils on the armature, with five layers in each coil. No. 21 single or double cotton or silk covered wire is used. It requires about 28 feet of wire for each coil. The winding is a slow and rather laborious process. The length of wire for a coil is wound on a sort of shuttle-stick $\frac{3}{4}$ inch wide, 12 inches long, with a notch in each end. The end of the wire is wrapped twice or three times around the ring over a piece of stout thread, which is tied around the wires to fasten them together, to begin a coil. Of course, the beginning is at one of the marks on the ring.

Now the shuttle is passed through the ring and brought back over the outside until one layer covers one space; then commencing the winding over the first layer the second is laid on, then the third, fourth, and fifth; all the layers are wound in the same way. The last three or four turns are made over a stout thread, which is tied when the last convolution is made.

The other coils of the armature are made in the same way, and when the winding is all on, the end of one coil is twisted with the beginning of the adjacent coil. A piece of well seasoned hard wood, hard maple, for example, is bored to receive a piece of $\frac{3}{16}$ inch drill rod—Stubs or something equally good—which constitutes the shaft. This rod is 4 inches long. A $\frac{1}{16}$ inch hole is drilled transversely through it at or near the center to receive a short pin which enters a slot in the end of the wooden hub.

This piece of wood is turned to fit the interior of the armature, and is cut off about the same length as the armature. The coils of the armature and the wooden hub are now varnished with thin shellac varnish, and allowed to dry thoroughly. The armature ring is then slipped into its place on the wooden hub, and the hub and the ring are coated with two coats of shellac varnish, one coat being allowed to dry before applying the other.

The next thing to claim attention is the commutator. This is a piece of wood fitted to the armature shaft and turned to fit a piece of brass or copper tube $\frac{5}{8}$ or $\frac{3}{4}$ inch in diameter and $\frac{3}{4}$ inch long. This tube is divided into five divisions, and parallel lines, preferably slightly spiral, are drawn from the divisional points marking the places where the tube is to be sawed to form the commutator bars. But before sawing, each end of each space which is to form a bar is drilled, and the hole is countersunk to receive a small wood screw, which passes into the wood and holds the bar in place when the brass tube is sawed on the lines to separate the bars. After sawing, the commutator is turned smooth and round, or filed in the lathe with a

smooth file. The screws used in fastening the commutator bars must not touch each other or the shaft.

The twisted terminals of the coils are now stripped of the winding at the ends and soldered to the commutator bars, having been cut off the proper length to reach to the commutator.

Before soldering, however, the ends of the terminals and a small portion of each commutator bar are tinned to facilitate the work of soldering. To tin the copper

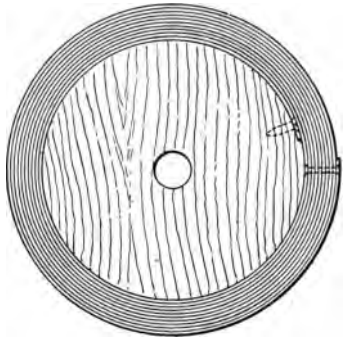


FIG. 240. The Armature Core.

wire, a little pulverized rosin is rubbed on the ends of the wires, and the solder is applied with a soldering iron.

The commutator bars are tinned for $\frac{1}{8}$ inch at the ends nearest the armature ring in the same manner.

The terminals of the armature coils are bent so as to touch the commutator bars at the tinned surfaces; the beginning of one coil and the end of the adjacent coil being thus brought into contact with a commutator bar. They are then soldered by applying a drop of solder by means of the soldering iron. The wires are

thus made to answer the double purpose of conveying the current to the commutator bars and of causing the commutator to revolve with the armature. Acid must not be used in soldering electrical connections.

To run smoothly, the armature must be in balance. To ascertain whether it is in balance, place the armature shaft on the edges of two level straight-edges supported about 4 inches apart. If the armature will stand in any position, it is balanced. If it rolls so that one side after a few oscillations of the armature goes to the bottom, the top must be made heavier to counterbalance the bottom. Probably the best way to add weight to one side of the armature is to apply it in the form of solder to a band of wire about $\frac{3}{8}$ inch wide wound around the armature. Before this winding is applied, a strip of mica $\frac{5}{8}$ inch wide must be wrapped around the armature and secured in place by shellac varnish applied to both the armature and to the mica and allowed to become nearly dry. It is not necessary to use a continuous piece of mica; it may be in several pieces. When the armature comes to rest after oscillation, solder should be applied to the upper side of the wire band until the armature will stand in any position. If too much solder is applied, the surplus may be removed by a coarse file. It is important to have the armature as nearly in balance as possible. It will then have very little vibration, or none at all, while running at any reasonable speed.

Care should be used in all the operations connected with this motor to insure entire success.

The next thing to be done is to construct the field magnet, which in this motor is in the form of a ring, as shown in Fig. 241. The core of the field magnet is

formed by winding four strips of No. 24 sheet iron $\frac{3}{4}$ inch wide and 8 feet long upon a wooden core, as in the case of the armature core. The form on which the field magnet is wound being $\frac{3}{16}$ inch larger in diameter than the armature, and as this is variable, it must be ascertained after the armature is wound and balanced, on account of the variation in the winding depending on the covering of the wire and the care with which it

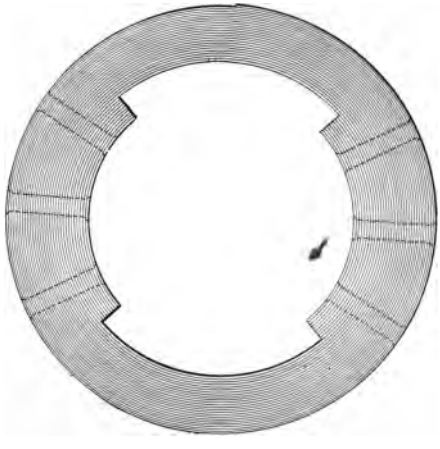


FIG. 241. Field Magnet Core.

is wound. In the motor illustrated, the field magnet ring is $2\frac{3}{4}$ inches internal diameter and $4\frac{1}{2}$ inches external diameter. Before winding the field magnet core, the ends of the 8-foot strips are scarfed or beveled off and tinned, and then soldered together and coiled for convenience.

The strips should be wound upon the form as tightly as possible, and when the last layer is on, a stout wire is wrapped around the outside and twisted together to

keep the sheet iron strip from unwinding, as in the case of the armature core.

As it is not necessary to anneal the field magnet, the wooden form is removed by boring a hole through it and then splitting the wood so that it can be removed piecemeal. The coil of sheet iron forming the field magnet core is composed of thirty-three layers.

The ring is divided into four quarters by radial lines, and midway between two of these lines, on opposite sides of the ring, are drilled holes for rivets $\frac{3}{16}$ inch in diameter, the holes being countersunk slightly on each side. These rivets with slight heads are inserted in the holes, with the heads inside the ring. They are then neatly riveted at the outside, leaving the inner side as smooth as possible. To accomplish this, it is necessary to move the binding wire away from the center of the field magnet ring.

When the two rivets are in place, the binding wire may be removed; then in the same sections near the ends are placed rivets, one at each end of each section. The sections riveted in this manner form inwardly projecting pole pieces. While drilling the holes for the rivets, it is necessary to clamp the strips firmly together to prevent the drill chips from working in between the layers of the magnet. Eleven layers of the magnet ring are sawed out between the pole pieces to make a space for the winding of the field magnet; the ends of the pole pieces are beveled as shown to facilitate winding. These spaces are covered with adhesive tape and are wound with four layers (about 45 feet) of No. 18 magnet wire, either single or double, cotton or silk covered.

One of the pole pieces will be at the bottom of the

field magnet and the other at the top when the motor is complete; therefore the winding on each side of the field magnet begins at opposite sides of the same pole piece, and is wound in the same direction to bring the wire terminals near the base of the machine, and

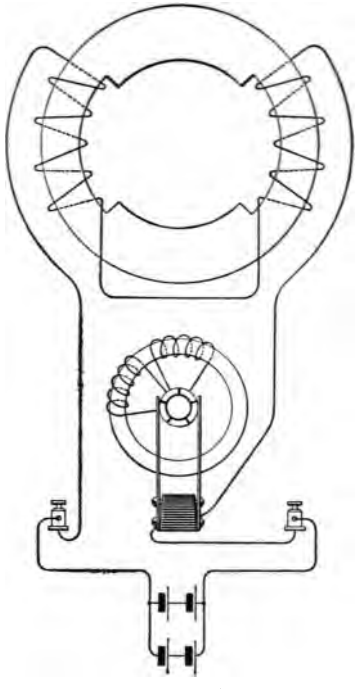


FIG. 242. Electrical Connections of Motor.

to cause the current in the two windings to unite in producing a north pole at the top of the magnet and a south pole at the bottom, or vice versa. If a mistake is made in the winding, this can be corrected in making the connections. It is not necessary to unwind and rewind.

The construction of this magnet is open to criticism on account of the disposition of the laminæ, but this construction is partly or wholly compensated for by the large rivets, which bind the pole pieces and the body of the magnet together.

The holes are drilled in the lower side of the magnet and tapped to receive machine screws, which pass upward through the base of the machine to hold the magnet, which latter sits upon a small wooden saddle about $\frac{1}{8}$ inch thick in the middle. The field magnet winding, as well as the iron core, is covered with several coats of shellac varnish, for insulation and protection.

The journal boxes for the shaft are simply $\frac{5}{8}$ brass balls axially bored to receive the shaft, and having an oil hole in the top. These boxes are each held in place by two brass plates bored to receive the sides of the balls as shown, and attached to the sides of the square wooden standards by screws. The shaft is allowed to project at one or both ends sufficiently to receive a pulley or fan. The armature is wrapped around the sides with enough firm paper to cause it to fit tightly into the field magnet, and after the shaft is made level, the journal boxes are placed on the shaft, and the standards which support them are sawed off the proper length and secured to the base by screws, one for each standard, passing upwardly through the base and into the lower ends of the standard. To the base adjoining the standard at the commutator end is attached a wooden block, to the ends of which are secured light copper springs, which bear on opposite sides of the commutator and act as brushes for conveying the current to the armature.

The screws which hold the lower ends of these brushes also clamp the wires which extend downward through the base, one being connected with one of the binding posts which receive the battery wires, the other brush being connected with the outside terminal of one of the field magnet coils. The outside terminal of the other field magnet coil is connected with the remaining binding post. The inside terminals of the field magnet coils are connected together. The connections are clearly shown in the diagram (Fig. 242). The upper screws in the commutator brushes are used for varying the pressure of the brushes on the commutator as may be required; the brushes being bent outwardly to admit of this adjustment.

If the motor is to be used for driving a fan, the base will need to be set upon legs of some kind. In the motor illustrated, the base is supported upon four inverted clothes hooks which support it 2 inches from the table.

The oil cups are made of wood (soft maple or birch), with stems extending down into the $\frac{3}{16}$ holes in the spherical boxes; and in the portion of the wood above the journal box is formed a cavity which will contain a few drops of oil. The outside of the oil cup is varnished with shellac except at the end of the stem, before any oil is put in. This confines the oil to the cavity and the interior of the stem and causes it to slowly feed to the journal on which the stem rests. The fan can be purchased for a small sum. It may be necessary to bush it to fit the shaft. Either an 8-inch or a 10-inch fan may be used.

Of course, a small pulley will be substituted for the fan when the motor is used to drive a machine.

If the motor when finished does not run in the desired direction, this may be changed by transposing the wire connections at the brushes, so as to change the direction of the current in the armature.

SMALL ELECTRIC MOTORS FOR AMATEURS

Every piece of electric work done by a student or amateur is of value, not only as an addition to his collection of apparatus, but as a means of acquiring a positive knowledge of electricity and of electrical apparatus. The following engravings show a simple and easily constructed motor, which very fully illustrates the construction and operation of the Gramme motor, and is well adapted to various uses requiring only a small amount of power.

This motor was built by Mr. W. S. Bishop, of New Haven, Conn., after the general plans of the simple electric motor already illustrated and described in a recent *Scientific American,* but the construction here shown is more simple and more easily carried out. The perspective view here given is two-thirds the actual size. The front and side elevations and the smaller detail view are full size.

The field magnet, A, is formed of a yoke of Norway iron $\frac{5}{16}$ inch thick, $\frac{1}{2}$ inch wide and $2\frac{1}{4}$ inches long. In the yoke, near its ends and $1\frac{5}{16}$ inches apart, are drilled holes for receiving the quarter inch Norway iron cores of the magnet, which are driven into the yoke.

The polar extremities, *a*, of the field magnet are curved to form a circular opening $2\frac{1}{16}$ inches in diameter. The winding of the field magnet may be applied

to the magnet cores, as shown in the engraving, or the wire may be wound upon spools fitted to the cores. The spools are 1 inch in diameter and $1\frac{1}{8}$ inches long between the heads. Upon each spool is wound 1 ounce of No. 24 double wound, cotton covered magnet wire. The yoke of the field magnet is fastened to the wooden base piece of the motor by screws passing upwardly through the base into threaded holes in the yoke.

The armature, B, consists of a small Gramme ring mounted upon a wooden disk secured to the armature shaft. The armature core, *c*, is a ring formed of a piece of annealed iron wire, No. 13 B. & S. gauge, having its ends beveled and drilled transversely to receive a pin, as shown in Fig. 246. A core of this kind, although theoretically not as efficient as a laminated core, answers every purpose in this very small motor, and greatly facilitates the construction of the armature. The core has an outside diameter of $1\frac{7}{8}$ inches. The outside diameter of the armature is 2 inches, and the inside diameter $1\frac{1}{2}$ inches. Upon the armature core are placed 12 coils, *b*, of silk covered, single wound magnet wire, No. 25 B. & S. gauge, separated by rings *d* of soft iron wire No. 13, the rings forming polar extensions which add to the efficiency of the motor. The armature coils are formed in a lathe on a mandrel, separately, as shown in Fig. 247. This mandrel consists of a piece of No. 11 wire having two collars $\frac{3}{8}$ of an inch apart, one of the collars being fixed and the other being removable. Each coil contains 4 feet 4 inches of wire wound in five layers.

To facilitate the removal of the coil from the mandrel, the first layer is wound loosely. After winding, and before removing the coil from the mandrel, the wire

is cemented with paraffine or wax melted on the coil with a warm iron. After twelve coils have been completed, they are strung upon the armature core, *c*, in alternation with the iron wire rings, *d*, and when the



FIG. 243. Perspective View of a Small Gramme Ring Motor.

core is filled, its ends are brought together and secured by means of the pin, as shown.

The wooden hub of the armature is now fitted to the ring, but before the ring is secured on the hub, twelve

equidistant holes are drilled transversely through the hub, near its center, and in each hole is inserted a piece of No. 12 copper wire one-half an inch long. The ends of the pieces of copper wire are allowed to project one-



FIG. 243 A. Perspective View of Small Gramme Ring Motor.

sixteenth of an inch beyond the sides of the hub. The ring is placed on the hub, and the ends of the wire projecting from adjacent coils, *b*, are twisted together and attached by means of solder to the copper wire pins

extending through the hub and forming the commutator bars, the covering being removed from the extremities of the wire. It will thus be seen that to each commutator bar is connected the beginning of one coil and the end of the adjacent coil, so that by means of

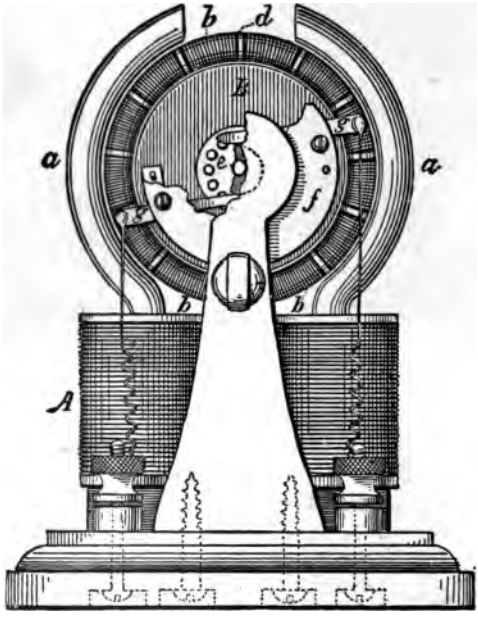


FIG. 244. Sectional Side Elevation of a Small Motor.

these connections the winding of the armature becomes continuous.

The posts in which the armature shaft is journaled are perforated near their upper ends with a hole of a size adapted to receive the armature shaft, and these holes are counterbored from the inner surfaces of the posts, and a wire of the same diameter as the shaft

is placed in the position of the armature shaft, and Babbitt metal or type metal is poured into the openings around the shaft, forming the journal boxes. A hole is bored in the top of each post before casting the metal, to form an anchorage for the journal box, and after the casting, the anchorage is drilled through to

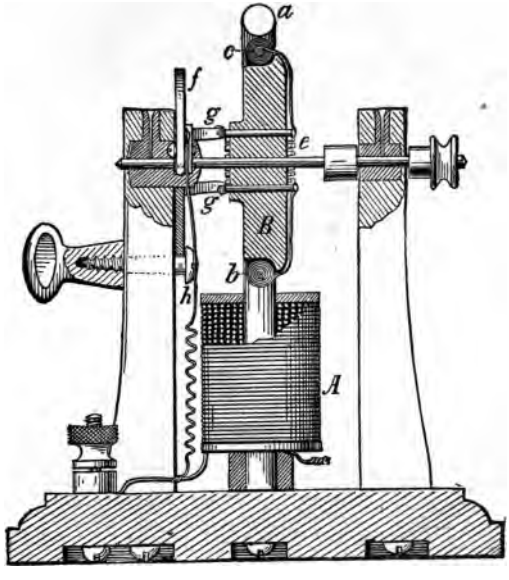


FIG. 245. Front Elevation of Small Motor.

the opening of the journal box to form an oil hole for the armature shaft.

The journal box on the side of the commutator is made to project beyond the inner face of the post to receive the disk, *f*, which carries the commutator springs, *g*. This projection is made by clamping to the post a piece of wood having in it a hole corresponding

with that in the post. After the journal box is cast, the extra piece of wood is removed, leaving a sleeve upon which to place the disk, *f*. This disk is an inch and a half in diameter and $\frac{1}{16}$ of an inch thick.

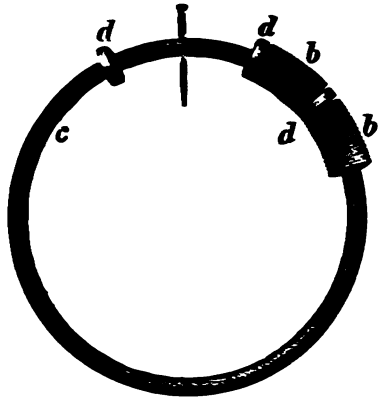


FIG. 246. Armature of Small Motor in Process of Construction.

To the inner face of the disk, *f*, are clamped the commutator springs, *g*, by means of small blocks, as shown in the perspective view, these blocks being held in place by screws passing through the disk into threaded holes

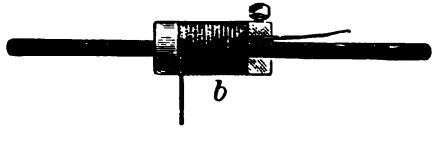


FIG. 247. Apparatus for Winding Armature Coils.

in the blocks. The commutator springs are curved outwardly and their ends are turned backward toward the disk, *f*, and their extremities rest upon the commutator bars, as shown in Figs. 243 and 244.

The disk, *f*, and the clamping blocks are made of vulcanized fiber, which is strong and at the same time a good insulator. The commutator springs, *g*, are made of hard rolled copper, and their inner ends are adjusted so as to touch diametrically opposite commutator bars. The best adjustment for the commutator springs is found by moving the disk, *f*, in one direction or the other. It will be found that the maximum effect is secured when the contact surfaces of the commutator springs are nearly in a vertical line.

The disk, *f*, is clamped in any desired position by an ordinary wood screw, *h*, which passes loosely through the post and is screwed into a wooden thumb nut bearing against the outer surface of the post. The terminals of the field magnet, A, are connected directly with the binding post and also with the outer ends of the commutator springs, *g*, as shown in Figs. 243 and 245.

With one cell of dry battery the motor makes about 1,800 revolutions per minute, but it does not develop its maximum power until one or two cells are added in parallel. Any of the dry batteries will run it for short periods, but if it is required to run it continuously for any length of time, one or two cells of Bunsen or a Fuller battery should be used.

The motor being shunt wound, is practically self-regulating. Its speed with any amount of battery power does not much exceed 2,000 revolutions per minute.

HOW TO MAKE A SEWING MACHINE MOTOR WITHOUT CASTINGS*

The accompanying drawings, together with the following instructions, will enable any mechanic of average ability to build a highly efficient motor that will operate the heaviest of family sewing machines with a

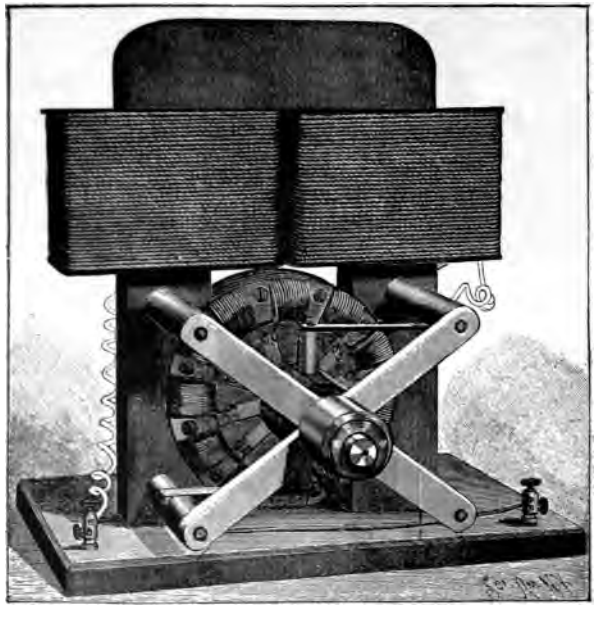


FIG. 248. Sewing Machine Motor Made by an Amateur.

consumption of electrical energy only a trifle greater than that required to maintain an incandescent lamp. All the materials entering into the construction of the motor may be procured in almost any town or small

* By Cecil P. Poole.

city, and the total cost of the machine, excepting, of course, the labor, should not exceed five dollars.

The first operation is that of making the magnet, which consists of a bar of ordinary wrought iron, $1\frac{1}{2}$ inches square and 19 inches long, bent (while red hot) into a U, as shown by Fig. 248. After bending the iron into shape, cut out two concavities in the limbs, as indicated by the dotted lines, to a circle of $4\frac{1}{4}$ inches diam-

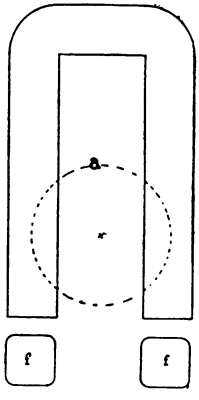


FIG. 249. Field Magnet.

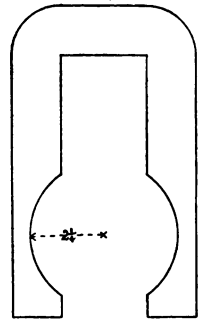


FIG. 250.

Field Magnet Ready for Armature.

eter. The center of the circle of which the concave surfaces form arcs must be $5\frac{1}{2}$ inches from the short part of the U, known as the magnet yoke, and exactly midway between the magnet limbs, so that an equal amount will be cut out of each limb. This cutting can be done by any blacksmith, as it does not need to be precise in the matter of the surfaces of the concavities, the only object being to remove the bulk of metal that is to be cut away in order to form the armature chamber.

Next smooth up the sides of the magnet on the flat of an emery wheel, rounding off the corners so that a face

view of the ends of the limbs will be as shown in Fig. 254: the faces, f, f, should also be smoothed off with the emery wheel, as these form the base of the machine. Then bolt the magnet to the face-plate of the lathe so that the center of the circle, *a*, to which the magnet limbs were cut away coincides with the lathe centers, and bore out the armature chamber to $4\frac{1}{2}$ inches in diameter, leaving the magnet as shown by Fig. 250; the curved surfaces forming the armature chamber are known as pole-faces. If the sides of the magnet (by "sides" are meant the part facing the reader in Figs. 248, 250, and 253, and the corresponding part on the other side of the magnet) were not ground to a true parallel on the emery wheel, and as it is highly probable that they were not, it is advisable to take a slight cut over the whole side exposed while the magnet is on the face-plate so as to have it perfectly plane, and also take a cut over the opposite side to insure parallelism.

The journal yokes and boxes come next. There will be two bearings and yokes, one for each side of the machine. Fig. 251 shows the parts necessary for one yoke and bearing; *y*, *y* are brass strips $6\frac{5}{8}$ inches long, 1 inch wide, and $\frac{3}{16}$ inch thick, with rounded ends; *b* is the box, made of a piece of round brass rod 1 inch in diameter and 2 inches long over all, one end being turned down to $\frac{3}{4}$ inch diameter for a distance of $\frac{3}{8}$ inch, a $\frac{3}{8}$-inch hole being drilled through the center and a $\frac{1}{2}$-inch hole being drilled in one side far enough to let the point of the drill through into the bore of the box; *c* is the oil reservoir, consisting of a piece of brass tubing 1 inch long, $\frac{5}{8}$ inch in diameter outside and $\frac{3}{8}$ inch diameter inside, with one end permanently stopped by a plug soldered in and the other end

threaded for a distance of $\frac{5}{16}$ inch. The hole in the side of the box, *b*, is threaded to match the thread on the end of the tube, *c*, which is packed with lamp wick, filled with oil, and screwed in the box when the machine is completed and ready to run. The yoke strips, *y*, *y*, have each a $\frac{3}{4}$-inch hole drilled exactly in the center, several nicks being filed in the edges of these holes. Before putting the yoke together, tin the edges of these central holes and tin the small end of

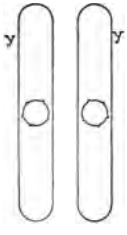


FIG. 251.



FIG. 252.
Parts of Yoke.

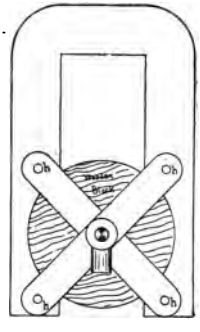


FIG. 253.
Placing Yokes in Position.

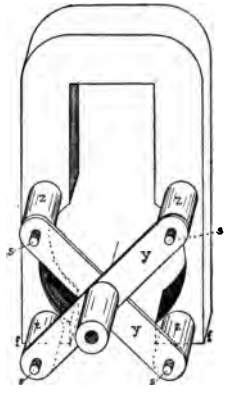


FIG. 254.
Magnet with Yokes.

the box, *b;* then mount the strips on the end of the box so they will be at right angles with each other and so that the hole in the side of the box comes between two of the legs formed by the strips, and solder the whole at the center. Be sure to fill the nicks in the edges of the holes with solder.

When both yokes have been assembled, turn up a block of wood $1\frac{1}{2}$ inches thick to fit closely the armature chamber in the magnet limbs without spreading the

latter. This block should have a $\frac{3}{4}$-inch hole in the center, and it will be better to drill the hole first, mount the block on a $\frac{3}{4}$-inch mandrel and turn it up true with the central hole. Put this block in the armature chamber with its $\frac{3}{4}$-inch mandrel in the central hole, thread one yoke on one end of the mandrel and the other on the other end, turning the legs of each yoke to the position shown by Fig. 253. Clamp the whole together securely and drill four $\frac{1}{4}$-inch holes, *h*, *h*, *h*, *h*, through the magnet limbs and both yokes; punch-mark one yoke and the face of the magnet limb on which it rests so that in reassembling the machine the various parts will come back to the original position in which they were drilled; then take off the clamps and take off the yokes, remove the yokes and wooden block and anneal the magnet by heating it to a bright red and allowing the fire to die out with the iron covered up in the coals.

For mounting the yokes permanently on the magnet, four steel machine screws and eight distance pieces will be required. The screws are $\frac{1}{4}$ inch in diameter and $6\frac{1}{4}$ inches long under the head, and the head should be slotted. The distance pieces to hold the yokes away from the magnet are made from round brass rod 1 inch in diameter; two of them are $1\frac{3}{16}$ inches long, two are $1\frac{3}{8}$ inches long, two are $2\frac{11}{16}$ inches long, and the remaining two are $2\frac{7}{8}$ inches long. Fig. 254 shows one yoke mounted, with its distance pieces, *z*, *z*, *z*, *z*, and *s*, *s*, *s*, *s*, represent the thread ends of the screws. The yokes should be carefully fitted or trouble may result from non-alignment of the bearings.

The armature structure comes next From some dealer in armature stampings procure one hundred rings of charcoal iron 4 inches in diameter outside and

3 inches in diameter inside. These rings must not be over $\frac{1}{10}$ inch thick and preferably about $\frac{1}{16}$ inch thick. Not all of the one hundred will be needed, but many will be spoiled in drilling. From a dealer in electrical supplies procure two rings of vulcanized fiber, the same diameter outside and inside as the iron rings, and $\frac{1}{4}$ inch thick. On the face of one ring space off twelve equidistant points on a circle scribed around the center of the ring's face midway between edges, as shown by Fig. 255, in which the points are indicated by

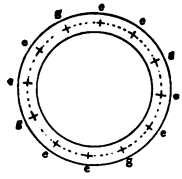


FIG. 255.
Laying Out the Armature.

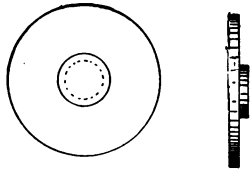


FIG. 256.
Brass Disks.

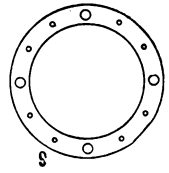


FIG. 257.
Position of Holes for Bolts.



FIG. 258. A Trapezoid.



FIG. 259. Tie Rod.

e, e, g, e, e, g, e, e, g, e, e, g, those marked *g* being 90 degrees apart. Take two brass disks 4 inches in diameter $\frac{1}{4}$ inch thick, with a $\frac{1}{4}$-inch boss $1\frac{3}{8}$ inches in diameter on one side, as shown by Fig. 256, which may be obtained from any model making establishment, and drill through the center a $\frac{3}{4}$-inch hole, indicated by dotted line in the sketch. Clamp on the smooth side of one of these disks the fiber ring that has been scribed, letting the marked face come uppermost, and drill four $\frac{1}{4}$-inch holes at the points marked *g, g, g, g,* on the

face of the ring, through both the ring and the brass disk. Next mount on a ¾-inch mandrel a block of wood 2¼ inches thick and large enough to permit turning it down to a roller 3 inches in diameter; instead of turning it to measurement, however, make it fit snugly into the interior of the iron and fibre rings. When this block is turned to size, thread on one end of the mandrel the brass disk that has only a central hole, next put the unmarked fiber disk on the wooden block, down to the brass disk, and follow with the iron rings, putting on last the fiber ring that has been drilled and then threading on the mandrel the brass disk that was also drilled with the fiber disk. Turn the disk so that the holes near its edge agree with those in the fiber ring under it and compress the whole arrangement with clamps. If there are so many iron disks that the fiber ring cannot be drawn down over the end of the wooden centering block, take off enough to let this be done, as it is imperative that all the rings and disks should be accurately centered with each other. Then drill ¼-inch holes through the whole mass, entering the drill in the holes already bored in the top brass disk and fiber ring. These four ¼-inch holes are for tie-bolts to hold the armature core together.

When the drilling is finished, punch-mark each brass disk and fiber ring near one of the ¼-inch holes (the same one in each case, of course), remove the clamps and the brass and fiber pieces, run a wire through the hole in the iron rings corresponding to the one marked on the fibers and disks and tie them loosely together until time to assemble the core. Then clamp the two fiber rings together, with the marked holes in alignment, and drill through both rings a $\frac{1}{16}$ inch hole at

each point marked *e*, leaving each ring as shown by Fig. 257.

Next cut out of hard wood twenty-four trapezoidal blocks (Fig. 258) $\frac{3}{8}$ inch thick, $\frac{3}{8}$ inch wide at one end, $\frac{1}{8}$ inch wide at the other, and $\frac{1}{2}$ inch long. In the center of sixteen of these drill a $\frac{1}{16}$ inch hole; in the center of the other eight drill a $\frac{1}{4}$-inch hole. Pin the sixteen trapezoids having small holes to the faces of the two fiber rings, putting the pins through from the back through the $\frac{1}{16}$ inch holes in the rings; the pins, which must be of brass, should be a tight driving fit so that the trapezoids will not tend to slip off, and the faces of the latter should be coated with shellac varnish to prevent their turning on the pins.

The tie-bolts, mentioned above, are of brass, $\frac{3}{16}$ inch in diameter and $3\frac{5}{8}$ inches long, threaded at each end for a distance of $\frac{5}{16}$ inch. They must be insulated where they pass through the core by wrapping paper on them, gluing each layer and putting on enough to make the insulated portion fit snugly in the $\frac{1}{4}$-inch holes drilled through the rings. Cut a strip of manila paper $2\frac{1}{2}$ inches wide and wrap it tightly on the bolt, leaving an equal length of uncovered metal at each end. When the right thickness of insulation is obtained, drill two $\frac{1}{16}$ inch holes in the bolt, exactly $2\frac{1}{16}$ inches from center to center, and equal distances from each end (this distance, if the bolt has been accurately cut to the length specified, will, of course, be $\frac{9}{32}$ inch). Two nuts must be also provided for each bolt, and two steel pins which are driving fits in the $\frac{1}{16}$ inch holes, and slightly tapered. One of these tie-rods, without its nuts and pins, is shown by Fig. 259.

Then assemble the armature core on its wooden cen-

tering block, using enough iron disks to make the iron part measure 1¼ inches in thickness when compressed and being careful to have those of the ¼-inch holes that were marked on the fibre pieces come in line with the hole through which the wire holding the iron disks together was run. Leave off the brass disks for the present. Through each ¼-inch hole put a tie-rod, clamping the structure until the steel pins can be put in the holes in the tie-rods; enough iron disks should be put in to prevent any looseness when the clamps are removed. Fig. 260 shows the complete structure. After

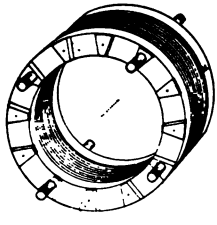


FIG. 260.
Armature Ready for Winding.

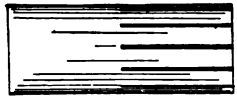


FIG. 261.
The Slitted Tube for Commutator.

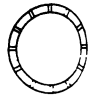


FIG. 262.

the tie-rods are pinned in place the remaining trapezoids are put on over the ends of the rods; a little groove will have to be cut in the back of the trapezoid to accommodate the steel pin in the end of the tie-rod.

The commutator comes next, and while it would be advisable to buy a complete commutator, a very serviceable one can be made with proper care in following out the instructions given. If the builder prefers to buy the commutator, the dimensions accompanying the order must be these: Diameter of brush surface, 1 inch; length along the shaft, 1½ inches; number of

segments, 12. If the commutator is to be built along with the rest of the machine, proceed as follows:

Take a piece of brass tubing, 1 inch in diameter outside, with a wall about $\frac{1}{8}$ inch thick, and measuring $2\frac{1}{2}$ inches long. Slit it at twelve equidistant points for a distance of $1\frac{1}{4}$ inches from one end, as shown by Fig. 261, and insert the unslitted portion in a hole in a block of wood that just fits the tubing; the block should be 1 inch thick and nailed to a bench or other support. Then bend outwardly the narrow strips made by slitting the tubing until it looks like Fig. 263; the wings should be brought to a right angle with the body of the tubing not slitted, and hammered out flat. Number the "wings" by means of punch marks, from one up to twelve, and then carry the slits along the length of the uncut portion of the tube, cutting it up into twelve pieces like Fig. 264. Next turn up two rings of vulcanized fiber 2 inches in diameter outside, 1 inch in diameter inside and $\frac{1}{4}$ inch thick, and fit around the circumference of each twelve steel screws, $\frac{1}{8}$ inch in diameter and $\frac{3}{4}$ inch long over all, without heads, as shown by Fig. 265, the screw-holes being carried clear through so that the point of the screw may emerge on the inside of the ring. Cut thirty-six strips of oil paper (the kind used with copying books to protect the leaves from moisture) $\frac{1}{64}$ inch thick, $\frac{1}{4}$ inch wide, and $1\frac{1}{2}$ inches long. Assemble the pieces of the commutator in numerical order within the two fiber rings, one ring at the wing end and one at the other end of the tubular part, put three slips of oil paper between each pair of neighboring pieces of tube, and draw the segments toward the center by means of the little screws until the oil paper slips are clamped so

tightly between the brass segments that they cannot be pulled out with the fingers. In order to have the commutator come together and form an approximately true circle, a saw blade $\frac{1}{32}$ inch thick should be used in cutting the segments out of the tube. Then by judi-

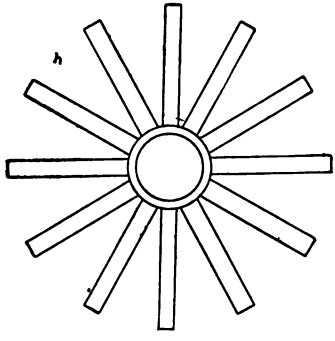


FIG. 263.
Commutator Tube Before it is Cut into Segments.

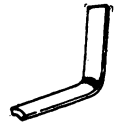


FIG. 264. One Segment.

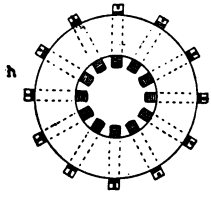


FIG. 265.
Fiber Ring with Screws.

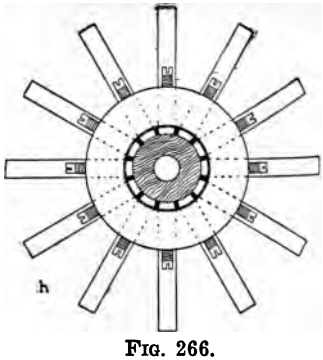


FIG. 266.
The Commutator.

cious setting up on the screws the surface can be brought sufficiently near to a true circle as to require no truing up in the lathe. The protruding edges of the oil-paper slips can be cut off even with the brass with a sharp knife.

The core of the commutator may be made of wood;

mount a block on a $\frac{5}{8}$-inch mandrel and turn it up to the exact diameter of the interior of the commutator; then taper it slightly so that it will pass through the commutator before binding, and drive it home as tight as possible without straining the fiber rings that hold the segments. Cut off the block $\frac{1}{8}$ inch beyond the wing end of the commutator and flush with the other end. The complete commutator is shown by Fig. 266.

The next piece of machine work is the shaft, shown by Fig. 267. It is turned up from a piece of $\frac{7}{8}$-inch bar steel $10\frac{1}{2}$ inches long. The dimensions are as follows: *A*, $\frac{3}{8}$ inch diameter, $2\frac{1}{16}$ inch long; *B*, $\frac{5}{8}$ inch diameter, $1\frac{1}{2}$ inches long; *C*, $\frac{3}{4}$ inch diameter, $3\frac{3}{4}$ inches long; *D*, $\frac{3}{8}$ inch diameter, $3\frac{3}{16}$ inches long. Last in the list of machine work on the motor proper are the brush holders, one of which is shown by Fig. 268, the drawing showing two views. The holder is a piece of brass tubing, $\frac{1}{2}$ inch internal diameter and $1\frac{1}{2}$ inches long. mounted on a piece of strip brass $\frac{5}{8}$ inch wide and $\frac{3}{32}$ inch thick, the other end of which is bent into a loop, as shown, and provided with an insulating bushing, *t*, of $\frac{1}{16}$ inch fiber. The internal diameter of the bushing is a trifle over an inch when the clamping screw is loose, and the diameter of the loop in the brass strip is, therefore, $1\frac{1}{8}$ inch maximum. This loop is intended to fit around one of the distance pieces, *z*, Fig. 254, from which it is insulated by the bushing, *t*.

The brush is a piece of round carbon, $\frac{1}{2}$ inch in diameter and 1 inch long; it should fit snugly within the tube forming the holder, and a spiral spring, $\frac{3}{8}$ inch in diameter, made of No. 16 brass wire, must be provided to force the brush outwardly on to the commutator. One brush holder is attached to the lower

left-hand distance-piece, *z*, and the other to the upper right-hand piece, the tubular part of the holder setting vertically, between the magnet poles, with its inner end not more than $\frac{1}{8}$ inch from the surface of the commutator. Electrical connection is made with the brush arm by means of a piece of flexible cord, such as is used in hanging incandescent lamps, one end of the cord being soldered to a copper washer, which is clamped under the head of the screw on the brush arm. This cord is known as No. 18 cotton-covered lamp-cord, and may be procured from any dealer. It should be untwisted and one length used on each brush holder; the cord need not be more than 6 inches long.

We are now ready to wind the magnet and armature cores. The armature core must first be covered all around the outside surface with muslin; cut a strip 2 inches wide and 25 inches long and, after varnishing the periphery of the core with shellac, wind on this muslin strip, being sure that it is tightly wound. If it is pulled tight, it will make two layers; when the strip has been carried once around, varnish the surface of what is on the core, and then wind on the other layer of muslin. Then varnish the whole outside surface. Cut out 24 strips of oil paper, each $1\frac{3}{16}$ inches wide and 2 inches long, and bend up the edges, making the crease $\frac{1}{4}$ inch from each edge, so as to form shallow troughs the width of which will be the same as the space between the trapezoids on the end of the core; apply two of the troughs to the inside and outside circles of the core, as shown in Fig. 270, and tie them in place with No. 40 or No. 50 sewing cotton, one strand at each side of the trough. Then wind on an old cotton-spool 68 feet of No. 26 double cotton-covered mag-

net wire, hook the outer end around one trapezoid, as in Fig. 271, and wind into the wiring space between this trapezoid and its right-hand neighbor a coil the full width of the space, which should take 26 turns in

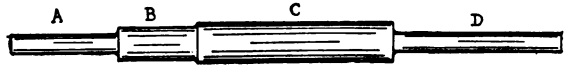
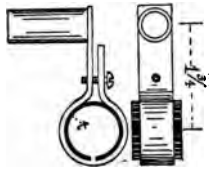


FIG. 267. The Shaft.

width, putting five layers in, or 130 turns, to each coil. When the first coil is done twist to the final end the beginning end of the wire which is to wind the next coil, and proceed with that one in the same way. Care must be observed to put exactly the same number of turns in each coil and to twist the ending of each coil to the beginning of its neighbor on the right. When the armature is wound, put on the brass disks that were left off when the core was assembled, threading the tie-rods through the holes near the edges of the



FIGS. 268 and 269. Brush Holders.



FIG. 270. Section Prepared for Winding.

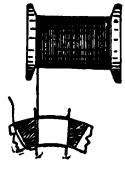


FIG. 271. Beginning the Winding.

disks, and putting the boss on each disk outside; clamp the disks hard against the wooden trapezoids by means of nuts on the tie-rods. The holes in the disks must be bushed with little pieces of fiber tubing and a fiber

washer must go under each nut, in order to insulate the tie-rods from the disks; otherwise the armature would run destructively hot.

Insert the shaft in the center of the structure, letting that part marked *B* in Fig. 267 come on the side where the ends of the armature winding are, and pin the brass disks to the shaft through the bosses. The commutator goes on the part of the shaft just referred to, and it should be a driving fit, so as to obviate pinning or keying it to the shaft. Then connect up the ends of the armature coils to the lugs of the commutator, leading each end straight out, parallel with the shaft, to the nearest lug. If the ends were twisted together in accordance with the directions, the result will be as shown diagrammatically by Fig. 272.

Prepare for winding the magnet coils by making a winding bobbin as follows: On a piece of board an inch thick and 4 inches square lay out a square measuring $1\frac{3}{8}$ inches on a side, the scribed square being symmetrical with the edges of the board; clamp another similar piece of board to the one marked, and at the corners of the scribed square drill $\frac{1}{4}$-inch holes through both boards; in the center of the square drill a $\frac{1}{2}$-inch hole. Then make a mandrel of $\frac{1}{2}$-inch round iron, the central part being full diameter and $2\frac{1}{2}$ inches long, and the ends being turned down to pass through the central hole in the board. Mount the boards on the ends of the mandrel and run $\frac{1}{4}$-inch iron rods through the corner holes, forming a sort of reel, as shown by Fig. 273. Jam the boards against the shoulders of the mandrel by means of lathe dogs on the outer ends of the latter, and drive a nail in the face of each board so that the dog will drive the board

without slip. The dogs must be so adjusted, of course, as to drive both boards in their proper angular positions, maintaining the parallelism between the ¼-inch rods and the mandrel that is necessary to form a perfect coil.

Mount this winding frame in the lathe and wind a coil on it of No. 21 double cotton-covered magnet wire, putting as many turns as possible (it should take sixty-six) between the faces of the wooden blocks and making the coil twenty-seven layers deep. The starting end may be secured to the projecting end of one of the ¼-inch rods to give the necessary tension to the first

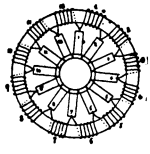


FIG. 272.
The Winding.

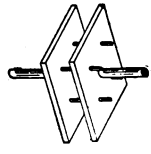


FIG. 273.
Reel for Winding Field Magnet Coils.

layer of wire, and at least a foot of the starting end should be left free. When the coil is finished, tie it at each of the four corners with strong linen thread, bending the final end sharply backward over one of these corner threads to keep the top layer snug; take the winding frame apart and varnish the coil all over with shellac, setting it aside to dry while the second coil is wound. This is exactly like the one already wound.

Then take the journal yokes and their bolts and distance pieces off the magnet and wrap the magnet limbs with muslin from ½ inch above the bolt holes up to the bend, putting two layers on each limb and

varnishing it on the outside of each layer. When this is dry, turn the magnet upside down, thread on each limb a fiber washer 3¾ inches square and ⅛ inch thick, the hole in the washer fitting the magnet limb snugly; varnish the faces of the washers now uppermost and slip the coils on the limbs down on the washers while the varnish is wet, so that the latter will stick to the coils. In putting on the coils, see that the beginning end of each coil goes on first, so that when the machine is set right side up the final end of each coil will be nearest the armature. Follow each coil with another fiber washer like those first put on the magnet, and then reassemble the journal yokes and distance pieces on the magnet, this time putting in the armature as you go along and also putting on the brush holders and brushes. The holders should be so adjusted that the ends of the brush tubes are $\frac{1}{16}$ to ⅛ inch away from the surface of the commutator.

The free ends of the magnet coils nearest the armature are connected to the brushes by means of flexible lamp cord, as described in the instructions for making the brush holders, the end of the flexible cord being soldered to the end of the magnet wire close up to the coil. Th upper ends of the magnet coils go to the terminal block, which is a block of wood, 1½ inches square and 4 inches long, bolted on the top of the magnet yoke, and carrying two binding posts, which form the terminals of the machine. The motor is bolted to the table of the sewing machine, with one leg right on the edge of the table and in such position that the pulley of the motor, which must go on the end of the shaft away from the commutator, is in line with the belt pulley of the machine. The motor pulley should be

one-half the diameter of the pulley on the sewing machine, and be of the same width and depth of groove.

The regulator is shown by Figs. 274 and 275, the former being the front view and the latter the back. Referring to Fig.. 274, *A* is a wooden arm, 9½ inches long, ½ inch thick, and tapering from ½ inch to 1¼ inches in width. The narrow end is faced with a thin strip of copper to make contact with the buttons, *c*, which are simple brass bolts with flat heads; the wide end of the wooden arm is split to straddle the shaft, to which it is pinned as well as clamped. *L* is the lever controlling

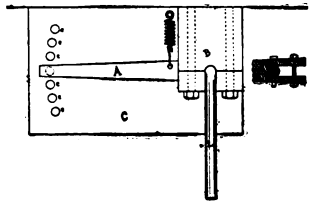


FIG. 274.
Regulator—Front View.

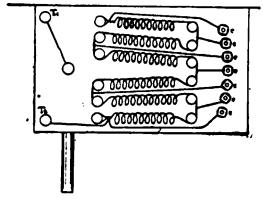


FIG. 275.
Regulator—Back View.

the arm, *A*; it is made of ½-inch round iron rod, bent to form a right angle; the lever portion is 6 inches long; the length of the horizontal portion on which the lever, *A*, is mounted is the same as the width of the sewing machine table on which the motor is to be used. The back end of the shaft is journaled in the base board, *C*, and the front part in a wooden bearing, *B*, which is bolted to the under side of the sewing machine table between the narrow drawer and the pan. The base board, *C*, is 6 inches wide (vertically) and 10½ inches long. It is fastened to the under side of the machine table, flush with the back edge. The lever, *L*, is to be moved by the right knee of the machine operator.

The arm, *A*, is normally held in its highest position by the coil spring shown, in which position the current is cut off the motor entirely. The contact buttons, *c*, are ½ inch in diameter; the bolts of which they are the heads are $\frac{3}{16}$ inch in diameter and long enough to protrude ½ inch on the reverse side of the base board. This side is shown by Fig. 275. The resistance coils consist of German silver wire, No. 20 B. and S. gauge, wound into coils on a $\frac{5}{8}$-inch rod (the rod being removed, of course, when the coil is formed). The piece of wire forming the upper coil should be 100 feet long; the next coils contain 90, 80, 70, 60 and 50 feet of wire, respectively, in the order named. The binding posts, T_1 and T_2, are connected as shown, the connection between T_1 and the iron shaft being made by means of flexible cord which will follow the movements of the shaft. On the front the shaft is connected to the copper facing at the small end of the arm, *A*, by means of No. 16 copper wire. All the connections on the back are made with No. 16 copper wire, preferably but not necessarily insulated.

The back surface of the base board must be covered with a sheet of asbestos over a thin sheet of fiber. The ends of the resistance coils are twisted together and soldered, and the connecting wires should be soldered on at the same time. The coils are held on ordinary porcelain knobs, fastened to the board by wood screws. The connecting wires should be bent into loops where they connect with the bolts, *c*, and a copper washer should go under each nut and on top of the loop of the connecting wire.

The connections between the motor and the regulator and the source of current supply are as follows: From

T_1 to one binding post on the motor, from T_2 to one side of the supply circuit, and from the other binding post on the motor to the other side of the supply circuit.

The motor above described will run satisfactorily on any direct-current incandescent lamp-circuit of 100 to 120 volts pressure. If it is desired to build the machine for use in connection with a battery, the windings will have to be changed as follows: Armature coils, No. 13 wire, 8 turns wide and 1 deep, each coil; field magnet coils, No. 8 wire, 5 layers deep, 18 turns per layer, each coil; regular, No. 13 wire, the coils having one-tenth the number of feet specified above.

The battery to run such a motor must give 8 volts and from 10 to 20 amperes, according to the load on the motor; consequently four cells will be required.

Should the reader desire to build a standard shunt-wound motor of $\frac{1}{6}$ horse power instead of the series-wound type specified, the same frame may be used, the only variation being in the manner of winding. In order to wind the machine as a $\frac{1}{6}$ horse power motor, to work on a 110 volt circuit, the armature coils must consist of No. 27 wire, double cotton-covered, each coil being 9 layers deep and 28 turns in width—252 turns, total, per coil. The magnet coils will consist of No. 25 wire wound to a depth of 39 layers, with as many turns lengthwise as can be got in the space of $2\frac{1}{2}$ inches allotted for the coil length; with careful winding, 92 turns can be put in each layer, giving each magnet coil a total of 3,588 turns.

In order to change the design into a $\frac{1}{4}$ horse power motor, the magnet must be made of iron $2\frac{1}{2}$ inches square, instead of $1\frac{1}{2}$ inches, and the armature, shaft, journal-yoke bolts, etc., must be made exactly 1 inch

longer, axially, than the above measurements specify. The windings will be No. 24 wire on the armature, each coil 5 layers deep and 21 turns wide; No. 22 wire on the magnet, each coil being 37 layers deep and 74 turns long (or as many as the 2½ inch space will take). The number of armature coils and all other data not specified in this paragraph will remain precisely as in the original instructions above.

A DESIGN FOR AN ELECTRIC LAUNCH MOTOR

For the propulsion of an electric launch a motor must unite elements of efficiency, compactness, and strength to a degree scarcely necessary in any other situation. The design given here is for a motor of unusual simplicity of construction, which can easily be built by an amateur at small cost. It is intended for a boat of about 24 feet over all and 4 feet 6 inches beam, drawing 18 inches, and is capable of propelling such a craft at a speed of 7 miles per hour. Gearing of all sorts has been dispensed with, the motor being adapted for direct attachment to the propeller shaft. While the description below refers primarily to a motor for a craft of this size, dimensions are also given for the construction of motors for smaller launches.

Without going into the details of calculation, it may be stated that for such a boat the most efficient service will be had from a four-bladed screw, about 14 inches in diameter, 12 inches pitch, 35 per cent. blade area (by which is meant with blades having a total projected area equal to 35 per cent. of that of a 14-inch disk),



FIG. 284. Transverse Section of Launch.



FIG. 276. Longitudinal Section of Launch, Showing Interior Arrangements.

running at 880 revolutions per minute. Such a screw will absorb about 4 horse power. No very definite figures of speeds and powers can be given, as these depend very largely upon the shape of the boat, its fullness fore and aft, the moulding of the runs, etc. The motor described below will give a speed of 7 miles per hour to a rather full-modeled boat of the size indicated, when fully loaded to a displacement of 5,000 pounds. This means, assuming that the boat itself weighs about 1,000 pounds, a carrying capacity for about ten or twelve passengers.

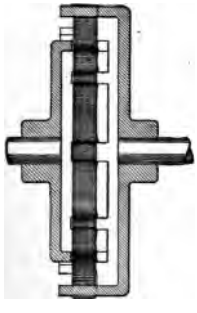
The storage battery consists of 24 elements, arranged in two series of 12 cells each, each cell being of about 80 pounds weight. These cells contains 13 plates each, about 7¾ inches square, and are about 7½x8½ inches square by 11 inches in height, these measurements being outside of the rubber containing jars. They should be mounted in two wooden boxes, about 8½ inches wide by 14 inches deep inside and about 7 feet 6 inches long. These make convenient seats in the boat, and their lids may be covered with cushions. They should be placed side by side amidships, as low as possible and a little forward of the center of gravity of the boat to compensate for the weight of the motor, which is installed well aft. Such cells may be bought from any one of several well-known American makers of accumulators. Elements in glass jars should not be used, on account of the danger of breakage.

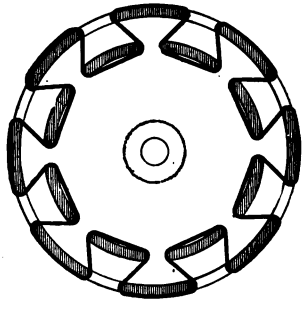
For the smaller sizes of motor described below, or, in other words, for smaller boats of the same general type, the number of cells remains the same, but their size may be proportionately reduced. With cells of the same type, having plates of the size given, a 3 horse

power boat will require those having 9 plates and a 2 horse power boat those having 7 plates.

Terminals for charging should be attached to the boxes containing the cells. It is by all odds the best plan to charge the cells in the boat, and not to attempt to remove them for this purpose.

The capacity of these outfits on one charge is about 3 hours' run at full speed, or about 7 hours' run at about 4½ miles per hour, thus giving the boat in each case a cruising radius of about 30 miles. If a larger





FIGS. 277 and 278. Section of Coupling.

cruising radius is desired, it may be attained by the use of larger cells, but, as these are heavier, their use means a corresponding decrease in the passenger carrying capacity of the boat.

The motor illustrated herewith is of a four-pole inclosed type, waterproof and intended to be attached directly to the screw shaft. Some form of flexible coupling is recommended, that shown in Figs. 277 and 278 being very simple and easily made. It consists of two cast iron flanges, the larger about 12 inches in diameter for the motor to be described and proportion-

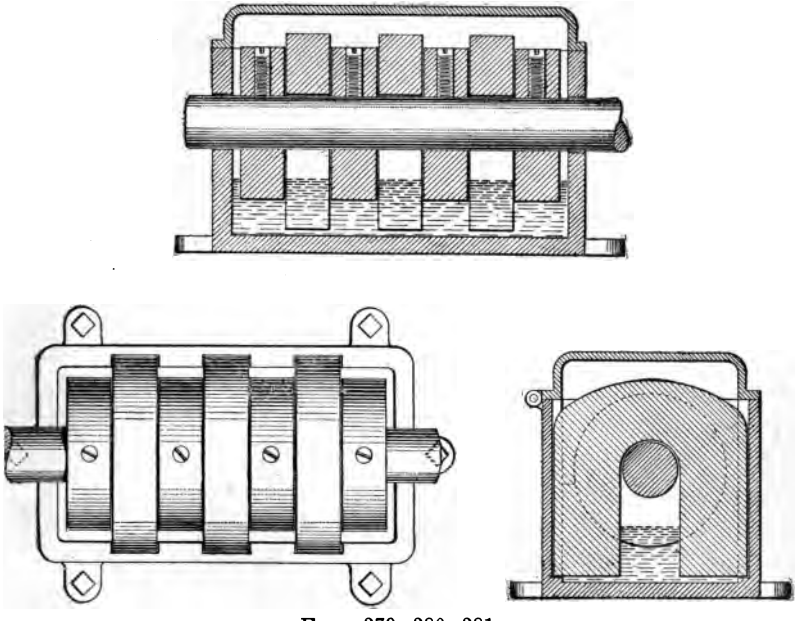
ately smaller for the smaller motors. These flanges are mounted, one on the motor shaft and the other on the propeller shaft, so that the smaller runs inside the larger, with a clearance of about 1 inch all round.

In the cylindrical surfaces of each are cut eight windows, the edges of which are rounded off as shown in Fig. 278. Through these windows a piece of cotton belting, 1 inch wide, is laced as indicated in the figure, its ends being cemented together. The whole forms an inexpensive and satisfactory coupling, which will largely prevent any strain of the shaft due to the flexure of the boat under loads in a seaway.

A thrust bearing, to take up the forward thrust of the screw shaft, is also necessary. A simple and satisfactory type is illustrated in Figs. 279, 280 and 281. Upon the screw shaft are mounted four steel collars, each about three times the diameter of the shaft and about 1 inch thick. These are provided with set screws. A cast iron box contains the brasses against which these collars work. This box, it must be remembered, receives the whole forward thrust of the screw, and must not only be made strong enough to resist this, but also arranged to communicate the pressure to the frame of the boat. A good plan for mounting it is to place in the bottom of the boat a stout timber, long enough to be screwed to several of the after frames, and arrange the thrust bearing with lugs for four or six lag screws so that it may be securely attached to this. In the size of boat described above, at full speed, the forward push of the screw will be about 220 pounds, but in a sea, or if there is any obstruction in the way, this may be easily doubled.

The box frame of the thrust block, as the illustra-

tions very clearly show, is grooved to receive three horseshoe shaped brasses, each about an inch thick. These straddle the shaft between the collars, which are adjusted to bear equally on the brasses. The box is filled with oil to a level so that the collars run in it, constantly lubricating the bearing surfaces of the collars



FIGS. 279, 280, 281.
Elevation, Plan, and Cross Section of Thrust Bearing.

and brasses. If one of the brasses heats, it may be lifted out and turned around or replaced with another without stopping the boat. A light hinged cover completes the thrust block. For the smaller sizes of motors indicated three collars on the shaft and two brasses will be sufficient.

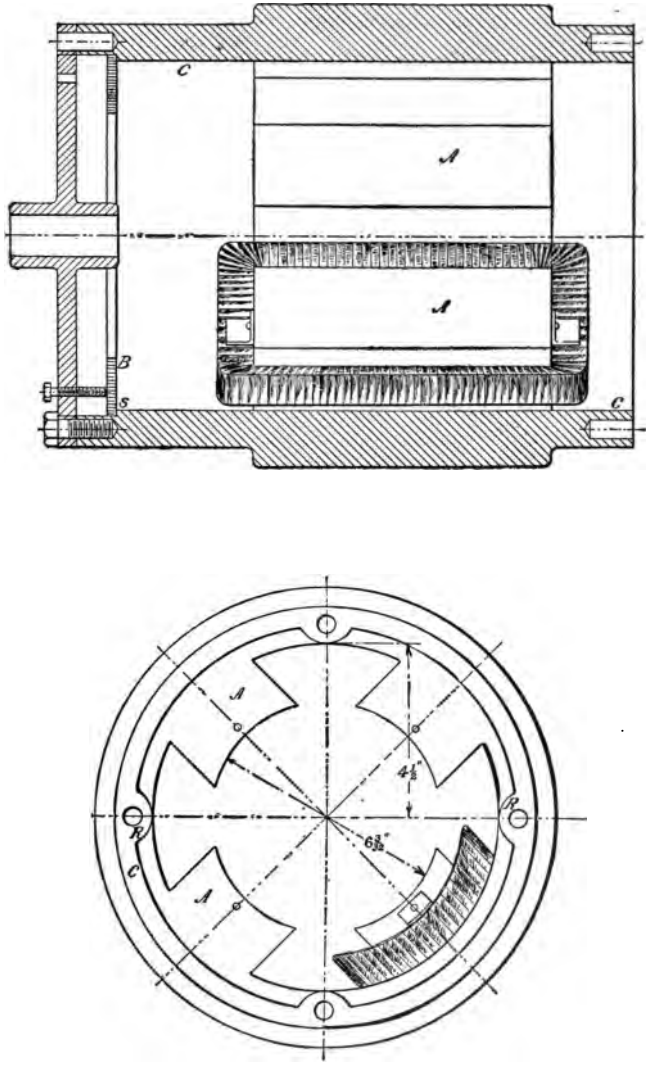
The shell of the motor, Figs. 282 and 283 is a cylin-

drical iron casting carrying the four polar projections, *A*. It is shown in the drawings with a perfectly plain exterior, but it should be provided with feet. These are not shown in the drawing, as they should be made to fit the shape of the hull.

At each end of the heavy field ring is a cylindrical projection, *C*, stiffened with four columnar ribs, *R*, to receive the cap screws which fasten on the end plate. The field casting may be finished on the lathe in two operations. It should be chucked and the field bored out to a diameter of exactly $6\frac{3}{16}$ inches. Upon the accurate boring of the field and turning of the armature, or, in other words, upon keeping the air spaces as small as possible, will depend much of the satisfactory performance of the motor.

The end surfaces for the reception of the end plates are trued off at the same time the field is bored, and the seat, *S*, for the brush holder ring, *B*, is also turned. There is no necessity for any finish on the exterior of the field cylinder or any other machine work upon it except drilling and tapping four holes in each end to take the cap screws holding on the end plates. After the field is bored all sharp edges and corners left on the polar projections should be neatly rounded off with a file.

The two end plates are exactly alike, each carrying a bearing $1\frac{1}{8}$ inches in diameter by 3 inches long for the armature shaft. They should be cast of bronze or gun metal, and need not be more than $\frac{1}{2}$ inch thick. In the one at the commutator end four windows should be cut, opposite the normal position of the brushes, so that these may be observed while the machine is running.



Figs. 282 and 283. Longitudinal and Cross Sections of Motor Shell.

The brush holder ring, *B*, Figs. 283 and 285, is of brass or bronze, $9\frac{7}{8}$ inches outside diameter and $\frac{1}{4}$ inch thick. It carries the four brush holders, one of which is shown in section in Fig. 285 and in elevation in Fig. 286. Any design of radial brush holder may be used, but the simple form shown is easy to make and very satisfactory. The body of it consists of a brass box, cast in one piece with the stud going through the ring, *B*. This is finished out to allow the coppered carbon brush, $1\frac{1}{2}$x$1\frac{3}{4}$x$\frac{3}{8}$ inches in size, to slide easily through it. A forked piece straddling the upper corner of this box carries a finger which is pressed upon the butt of the brush by the steel spring and thumb screw arrangement shown.

The dimensions of the shaft are clearly indicated in the drawing. The commutator is by far best bought, though the drawing furnishes a sufficient indication of a simple form to enable an amateur to make it himself if he so desire. It has 48 segments and should be 4 inches in diameter, 2 inches face, and bored for a $1\frac{1}{4}$ inch shaft.

The core of the armature is 6 inches diameter and 8 inches long. The end plates of steel, $\frac{1}{4}$ inch thick, hold together the mass of soft iron disks of which it is composed. These should be a little larger than 6 inches diameter in the rough, as the core must finish exactly to this figure. If it comes out a little small, the field bore, which should wait upon the construction of the armature, must be made as nearly as possible $\frac{3}{16}$ inch larger.

It is useless to japan or insulate the disks. Put them together as they are, tighten up the nut, *N*, Fig. 285, on the shaft and pin it in place. Then true off the

surface in the lathe by very light cuts with a sharp tool at rather high speed, using an abundance of soapy water on the tool. A mirror-like surface may be attained in this way.

While the armature is in the lathe it should be scored for the binding wires which will hold the coils in place. The grooves for these should be turned, each about $\frac{1}{2}$ inch wide by a scant $\frac{1}{16}$ deep, one near each end and one in the middle.

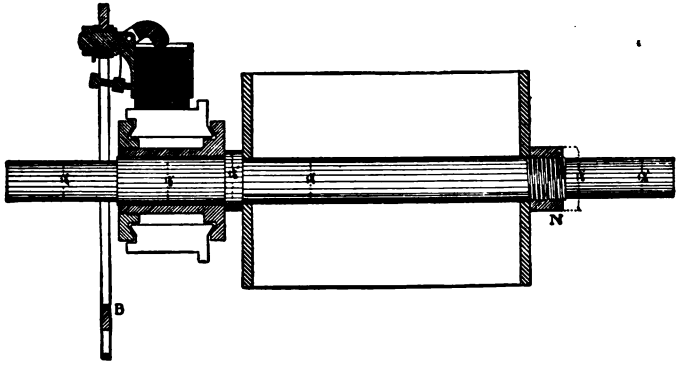


FIG. 285. Armature Core, Shaft, and Commutator.

The next operation is milling out the slots for the winding. There are 48 of these, each $\frac{1}{4}$ inch wide and $\frac{7}{16}$ inch deep, equidistantly spaced around the core. In milling out armature slots, the tool should turn at a fairly high speed, the feed be very slow and the cut light, and an abundance of oil should be used. If no milling machine is at hand, the slots may be planed, great precaution being taken to keep the cut very light indeed.

The best way to line up the frame of the motor and to be sure that the armature is properly centered in the

field bore, is to wrap the armature core with one or two layers of thin paper, until it fits neatly in the field bore, put on the heads at the ends of the machine, and cast Babbitt metal in the bushings. If the end plates are marked so that they can be put back in the same way, the armature will be found to be correctly centered. Unless this is done the electrical balance of the motor will be disturbed, and the brushes will probably spark and give trouble.

The winding to be described is of the sort known as a four-pole lap winding, and is one of the simplest and easiest to make of the various forms of interlocked windings. Each of the forty-eight coils used is shaped in the forming apparatus shown in Figs. 287, 288 and 289. This is in two parts, a frame for winding the coils and a former for bending them. The frame is simply a piece of board with two $\frac{1}{2}$ inch round metal pins driven in it, these being $10\frac{3}{4}$ inches apart, out to out. Around these, as clearly shown in Figs. 288 and 289, are wound six turns of No. 14 B. & S. gauge double cotton-covered wire, the starting end of the coil being marked by twisting a loop in it, as shown in Fig. 289. The ends of the wire should be left longer than the illustration shows them, say about 6 inches. When this coil is completed, it should be tied in at least four places with small thread to keep it in position when it is removed from the two pins, and it should be well shellacked with rather thin varnish. It is extremely advisable to make up at least five or six of the boards shown in Figs. 282 and 283, as this enables the winder to allow the coil to dry to the proper consistency of "stackiness" before it is removed from the frame, and also permits the coils to be made much more rapidly

than if it were necessary to wait each time for the wire to dry out before winding the next.

The correct state of dryness of the shellac for the next operation must be learned by experience. It is when it is at its stickiest. When this condition is reached, the coil is removed from the frame and placed in the apparatus shown in Fig. 287 to be formed. This machine is made of a wooden base board, on which is screwed a hard wood shaping piece of the dimensions shown and about ½ inch thick. Two hinged pieces, as shown, are provided, so that when the straight coil as

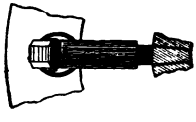
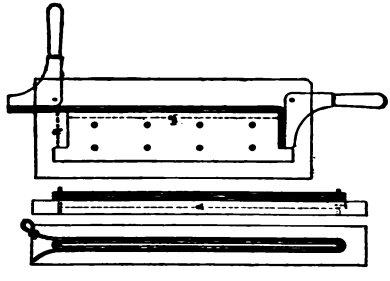


FIG. 286.
Brush Holder.



FIGS. 287, 288, 289.
Board for Forming and Bending Coils.

it comes from the winding board is laid centrally upon the forming piece, and both the hinged pieces bent over, it will be bent into a form somewhat like a wide inverted U. The illustration shows a coil of only one layer being bent. There will be, of course, six wires in each side of the coil, or twelve in all to be bent.

When this bending operation is completed, and before the shellac is finally hard, the bent coil must be pulled apart so that six of its wires, those tied together on one side, may be laid in a slot of the armature, and the remaining six wires, forming the other long

straight side of the bent coil, laid in the slot 90 degrees away. In other words, the coil, when it is put on the armature, must reach from slot 1 to slot 13, assuming that they are consecutively numbered. The appearance of the finished coil, ready to put on the armature, is indicated by Fig. 290.

A glance at Fig. 291, which shows the end of the armature partially wound, will make this clearer. The

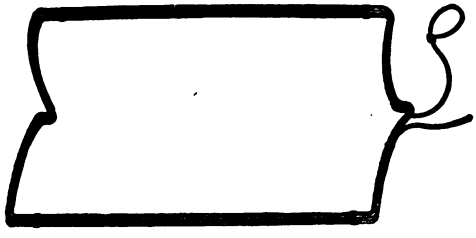


FIG. 290. Completed Coils, Ready to be Mounted on Armature.

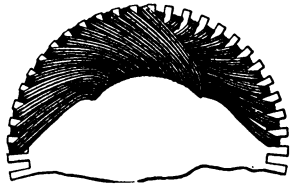


FIG. 291. End of Core, Showing Arrangement of Coils.

coils, if properly bent, will lie close together on the heads of the armature and produce the very neat and simple interlocked end arrangement shown in the illustration.

When all the forty-eight coils are in place, the armature is ready for banding. In the shallow scores on the surface are laid thin strips of mica, the armature being in centers on the lathe for this operation, or

otherwise mounted so that it can be turned around. It is better to catch the mica strips under a cord wrapped around the core a few turns than to attempt to stick them on with shellac. On the mica is wound the band, consisting of about No. 24 gauge German silver or hard brass wire wound under the strongest tension it will stand. The band should not be more than $\frac{3}{16}$ inch wide, the number of turns depending, of course, on the gauge of the band wire. Above all, care must be taken not to have this so large or the mica so thick that the bands project above the armature surface, as the clearance space is very small and the bands are liable to injury in putting the armature in place or removing it.

When the band wire is wound on, it is soldered with five or six little dabs of solder, not continuously, and the ends cut off. Three bands will be required, one within about $\frac{1}{2}$ inch of each end of the armature core and the other at the middle.

The commutator is held from turning on the shaft by a feather (not shown in the illustrations), and is sufficiently held endwise by the ninety-six wires soldered into it. To connect these, take the beginning end of any coil, marked by the little loop twisted in it, and solder it and the ending end of the next coil in regular order, either way, into the slot in the tail of the commutator bar nearest in line. Proceed around the armature in this regular order, being very careful to bring the ends out neatly and not to pull the head of the winding to pieces in so doing. No acid should be used as a flux in soldering commutator connections. The only safe thing is rosin. A narrow edged soldering iron that will go into the slot in the commutator

bar will be found very convenient for this work. It is well to wind some tape around the inner hub of the commutator before beginning the soldering. When it is finished, a layer of stout cord should be wound on over the bunch of ends going to the commutator to keep these from spreading from centrifugal action when the armature is running. These commutator connections, ready for the cord wrapping, are shown in Fig. 292.

The armature is completed by being returned to the lathe, where a light cut is taken over the commutator

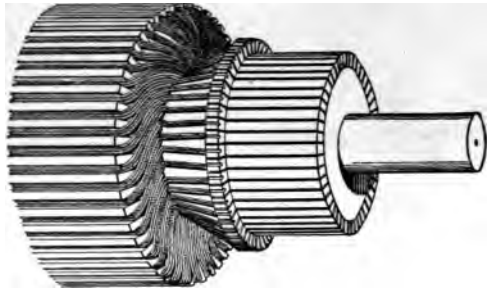


FIG. 292. End of Completed Armature, Showing Commutator Connections.

to true it and cut off any straggling wire ends. The armature should be baked over night in an oven to thoroughly dry it out before it is attempted to use it in the motor.

On each of the four poles of the field is fastened, with small brass angle pieces, as clearly shown in Figs. 282 and 283, a coil consisting of twenty-five turns of No. 6 B.& S. gauge wire, arranged in five layers of five turns each. These coils are wound on a wooden former and taped. Their inner ends should be marked in some convenient way, and they should be connected to-

gether so that they magnetize the fields alternately north and south when a current is sent through the four in series. Calling them *A, B, C,* and *D,* this is done thus: Bring out the outer end of *A* through a hard rubber bushing in the commutator end plate (the end plate at the commutator end of the motor), then connect the inner end of *A* to the inner end of *B,* the outer end of *B* to the outer end of *C,* the inner end of *C* to the inner end of *D,* and bring out the outer end of *D* through another bushing.

Two other bushings are provided for bringing out the ends of the wires to the brushes. The four brushes are connected in two pairs, opposite brushes being connected together and to one of the leading-out wires. These connections should be made with No. 8 wire and the leading-out wires should be No. 6 flexible rubber insulated cable.

Should it be desired to construct motors of this type, but of less power, the same general instructions should be followed, the diameter of the armature and casing being the same, but their lengths different. Below are given dimensions and speeds for motors of two and three horse power; where a dimension is not given, it is the same as that described above for the motor of four horse power. The slots for the three horse power armature should be $\frac{1}{4}$ inch wide and $\frac{1}{2}$ inch deep; for the two horse power armature, $\frac{1}{4}$ inch wide and $\frac{7}{16}$ inch deep.

The motor now being complete, the next part of the boat's equipment is the controller. The design shown is exceedingly simple and easy to make. Referring to Figs. 293, 294, and 295, which show it in section and Fig. 296, which is a diagram of its connections, it

construction and operation will be readily understood. It has been thought best not to complicate its construction by attempting to combine the ahead and astern controlling movements with those for speeds, so two handles are provided, one giving half the full speeds and the other for reversing the boat's direction. These are, however, for convenience, mounted at the two ends of the cylindrical case of the controller. The best material for this is wood. It should be about 10 or 12 inches in diameter outside, and about 1 inch thick

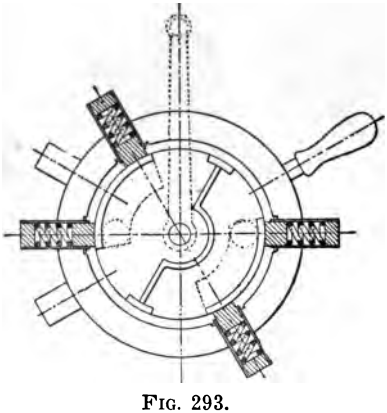


FIG. 293.
Cross Section of Speed End of Controller.

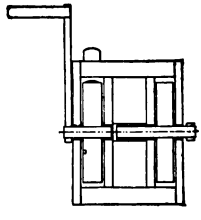


FIG. 294.
Longitudinal Cross Section of Controller.

by about 9 or 10 inches long, and is conveniently built up in the way described above for the pattern for the field casting. It should be of wood on account of the insulating properties of that material.

In this wooden cylinder are mounted two wooden disks, about an inch less in diameter than the internal measurement of the containing cylinder. These two disks are turned by the two handles—the speed and direction handles—and carry on their surfaces copper

sectors which are set into the wood so as to leave a smooth surface for running under the connecting points. These are well shown in cross section in Fig. 293, which is a partial cross section of the speed controlling end of the apparatus. They consist of brass tubes about 1 inch in diameter, 4 inches long, and $\frac{1}{16}$ inch thick, containing a spring and a contact piece (brass or copper), fitting the tube neatly and pressed by the spring into contact with the surface of the disk. Nine of them will be required.

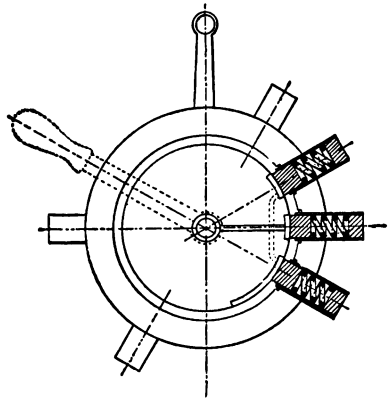


FIG. 295. Cross Section of Reversing End of Controller.

At the speed control end of the apparatus the turning disk carries two short sectors on opposite sides, these being connected together as shown, and two longer sectors extending through about 80 degrees of the circumference. These are also folded over on to the back of the disk, as shown by dotted lines in Fig. 286, so that two of the spring contacts may also bear upon this surface. The easiest way to make these sectors is to cut the parts out of $\frac{1}{16}$ inch sheet copper, and mount them

on the wood with small countersunk wood screws. The circumferential and flat parts of the sectors last described may well be soldered together after they are in place on the disk. In all cases the sector should be let into the wood so that there will be no shoulder to catch against the spring contact when the disk is turned.

At the speed control end of the apparatus four of the spring contact tubes are mounted, bearing upon the edge of the disk as shown; the four being in opposite pairs 60 degrees apart. In the interior of the cylindrical case of the controller are two partitions as shown in Fig. 294, the one nearest the speed control disk just described carrying two of the spring contacts bearing on the flat sectors as shown by the dotted lines in Fig. 293. These bear at points on the same diameter connecting two of the edge bearing contacts.

At the other end of the controller is mounted the mechanism for reversing, which is shown in partial section in Fig. 295. This consists also of a disk carrying on its edge three sectors, two of them only long enough to be entirely in contact with the spring contacts as shown, and the other long enough to bridge two of them, about fifty degrees. Three of the spring contacts are mounted bearing on these, 30 degrees apart. The long sector is connected to the further of the two short ones, while the middle sector is connected to the pivot of the disk and thus to the bushing in which it turns. As Fig. 294 shows, this is made quite long, as this contact has to carry large currents. It should not be less than three inches long, the pivot being a piece of one inch shafting.

Referring now to Fig. 296, the operations of the con-

troller will be easily understood. It shows the connections for half speed ahead. The diagram shows the two sides of the controller separated, for the sake of clearness, but it is, of course, understood that they are no further apart than the two ends of the wooden box in which they operate. The fuse shown in the circuit between the pivot of the reversing controller and the inner spring contact is mounted in the middle division of the box, which should have a door for access. It should be an ordinary single-pole porcelain fuse block

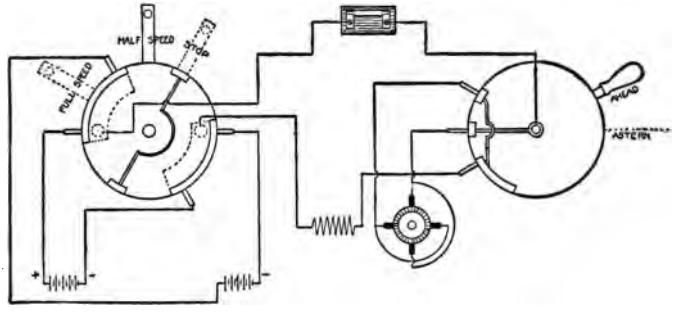


FIG. 296. Diagram of Controller Connections.

carrying a fuse blowing at about 75 amperes. For the 3 horse power motor it should blow at 60 amperes, and at 40 amperes for the 2 horse power motor.

The controller box is easiest made of some soft wood, such as white pine. It should be liberally varnished outside and lined inside with asbestos paper, glued or tacked in place. The two disks should be of hard wood. On the exterior of the box should be marked the positions for the various speeds and directions, or, if the constructor feels so disposed, he can mount a position cam and roller on each pivot.

The controller may be placed anywhere in the boat, but preferably where it can be manipulated by the pilot's left hand while he steers with his right. All the wiring between the batteries, motor, and controller should be run with good quality rubber covered wire, No. 4 gauge, and preferably in iron armored conduit, so that it may not be disturbed by passengers walking on it.

The 24 cells of battery may be conveniently charged from a 110 volt source of supply by the use of a resistance. This should be of about 3 ohms and is conveniently made of iron wire, about No. 14 gauge. About 350 feet of it will be required, and this may be conveniently coiled up in loose coils and hung in a frame. It should not be confined, but allowed to have free circulation of air, as it will warm up considerably. The charging current should be about 20 amperes. Full charge is determined either by the voltmeter, which will then read 50.5 volts, or by the "boiling" of the cells. It is a waste of current to attempt to further charge a cell after it begins to "boil."

If the amateur so desires he may make his own cells, but he is likely to have more satisfaction with those he buys. For the larger size of motor described these cells should be made with plates 8 inches square, 15 lead plates and 16 zinc plates to each cell.

THE EDISON DYNAMO OR MOTOR

It is one thing to make a dynamo or motor from explicit instructions and quite another thing to design a machine adapted to generate or be operated by a particular current. The former is purely mechanical

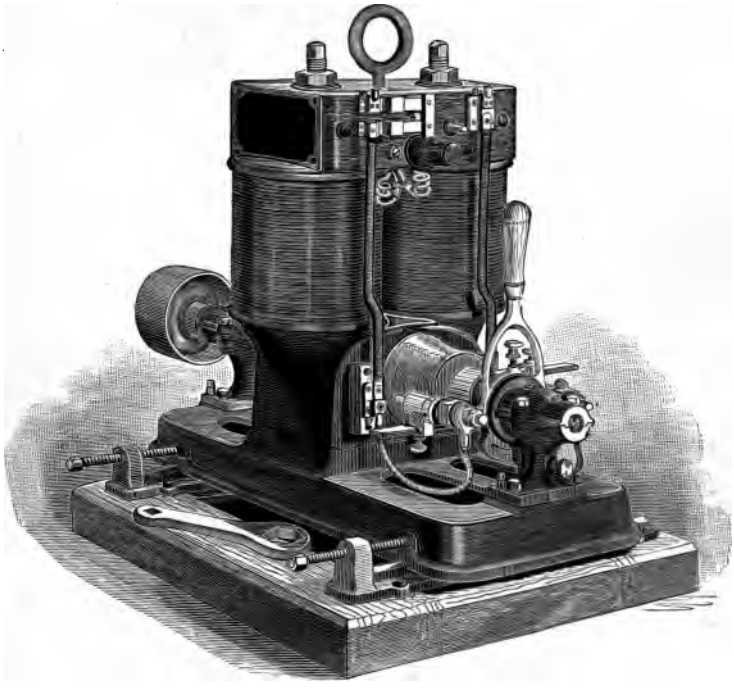


FIG. 297. Small Edison Dynamo or Motor.

and within the range of most machinists and amateurs, while the latter is entirely within the province of the electrical engineer or electrician. When the work of machine building proceeds simultaneously with the

study of fundamental principles, real progress is made. For the benefit of those who proceed in this way, and in answer to many inquirers, we give a detailed description of an Edison 0.25 kilowatt machine, designed for use as a dynamo for supplying a current for five Edison standard lamps, or for use on the Edison circuit as a quarter horse power motor.

Before beginning the description of the machine it is but fair to say that it is thoroughly well made in every particular. The insulation in every part is very perfect, and the whole is so well made that any single machine built by a mechanic or amateur could but suffer by comparison with it; and furthermore, we doubt if any maker of a single machine could even purchase the materials required for the price asked for the machine by the regular manufacturers. Therefore, if the machine is wanted, we advise a purchase. If experience is wanted, the making of the machine comes first in order, with a probable purchase to follow.

The base, which is of brass, is made hollow, as shown. It is 14 in. long, $7\frac{3}{8}$ in. wide, $1\frac{3}{4}$ in. deep at the ends, with two $1\frac{1}{8}$ in. elevations at the middle for receiving the cast iron pole pieces of the field magnet, which are each secured to the base by two small tap bolts extending upwardly through the base and into the pole pieces.

The upper surfaces of the pole pieces are truly faced for receiving the cylindrical field magnet cores, which are made of Swedish iron, $2\frac{5}{8}$ in. in diameter and $4\frac{1}{2}$ in. long. These magnet cores are each held in position by a threaded stud screwed into the pole piece and entering magnet core. Each core is provided with a vulcanized fiber collar at each end, which is $\frac{1}{4}$ in. thick

and $\frac{7}{8}$ in. wide.. Upon each core, and between the fiber collars, is wound 5¼ lb. of No. 24 silk-covered copper wire, with a wrapping of thin varnished paper between the layers. The cores, before winding, are thoroughly insulated with the same material. The

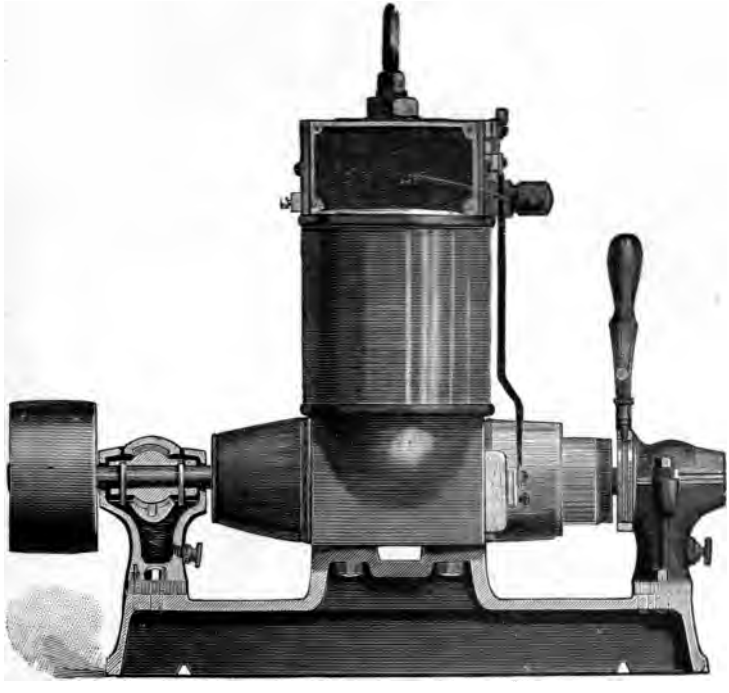


FIG. 298. Side Sectional Elevation of Dynamo.

fiber collars are each held in place by three conical-headed screws entering the end of the core, with their heads projecting beyond the body of the core. To the inner and outer ends of the winding of each arm of the magnet are attached pieces of larger wire to avoid

breakage, and the inner ends are led out through grooves in the fiber collars. The yoke, of Swedish iron, is $2\frac{5}{8}$ in. wide, $2\frac{1}{8}$ in. thick and $7\frac{1}{2}$ in. long. It is held in position on the cores by two $\frac{1}{2}$ in. bronze studs, each threaded at the upper and lower ends, and furnished with a collar which fits into the counter-

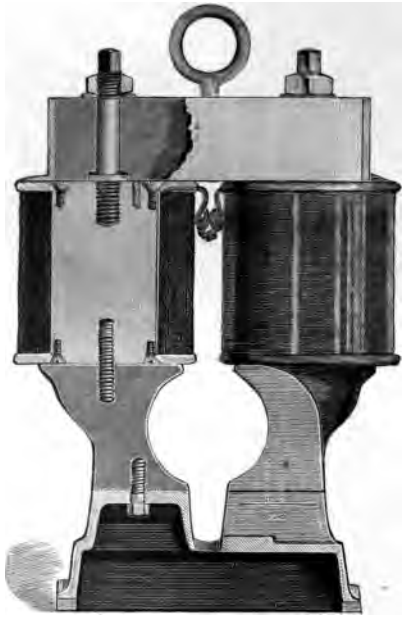


FIG. 299. Side View of Field Magnet, Partly in Section.

bored part of the hole in the yoke. The studs are squared at the upper end to receive a wrench, and a nut is placed on each stud above the yoke for clamping it securely after adjustment. The machine is regulated or adapted to any work requiring less than its full power by raising the yoke more or less. The yoke

is provided with an eye, by means of which the machine may be lifted.

Front and rear boards of mahogany are arranged on opposite sides of the yoke, and held in place by brass plates at the ends.

The outside ends of the field magnet coils are connected with binding posts on the rear board.

A variable resistance of ten or fifteen ohms is inserted between these posts when the machine is used as a dynamo. In the front board, at the right hand side, is secured a bronze casting known as the right hand motor head field magnet terminal. This is



FIG. 300. Switch on the Edison Dynamo or Motor.

adapted to receive the line wire, also one of the leads, the upper end of which is screwed to the casting. The lower end of the lead is secured to a lead terminal attached to a block of wood secured to the right hand pole piece. At the right hand side of the machine a similar arrangement of the lead is found, but the upper lead terminal is made in two separate parts, one attached to the lead, the other being connected with the line; both being furnished with copper switch tongues. The switch arm turns on a stud projecting from the front board and carries a loose triangular switch plate of copper, having a knife edge which

readily enters between the switch tongues. The switch has a T-handle of hard rubber, by means of which it is turned. A stop pin projecting from the front board limits the rearward movement of the switch arm.

The inside end of the right magnet coil is connected with the right hand lead, and the inside end of the left

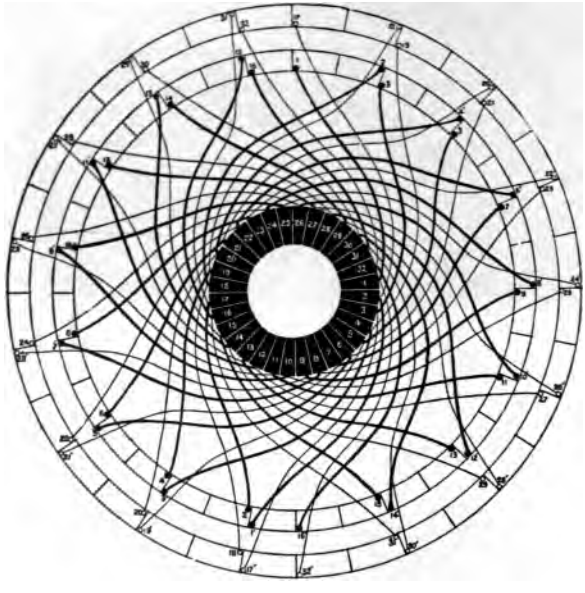


FIG. 301. Diagram of Winding of Edison Armature.

hand magnet coil is connected with the lower half of the left hand lead terminal.

At opposite ends of the base there are plane surfaces to which are secured the self-oiling bearings of the armature shaft. Each bearing has a hollow standard furnished with a cap, which, together with a cross piece in the hollow standard, forms a support for the

spherical central portion of the bronze sleeve forming the journal box proper.

This sleeve is shorter than the outer portion of the bearing, and is slotted across the top to allow two brass rings to ride upon the armature shaft. These rings dip in the oil in the hollow standard, and as they

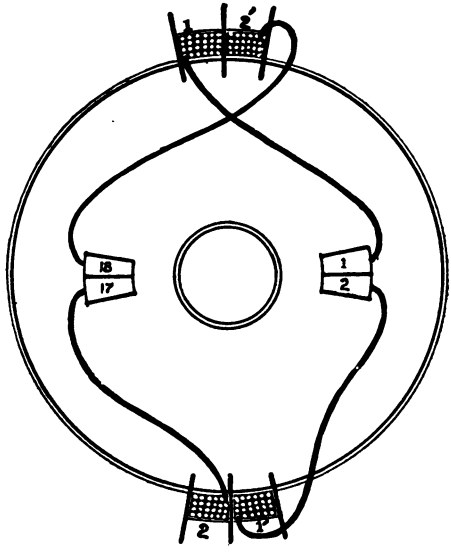


FIG. 302. The First Two Coils and Commutator Connections.

revolve carry oil to the shaft in quantities more than sufficient for the purpose of lubrication. The oil is distributed throughout the bearing by means of spiral grooves formed in the inner surface of the journal box. The surplus oil drops back into the hollow standard. A screw plug in the lower portion of the standard allows of the renewal of the oil. The bearings at

opposite ends of the machine are alike, except that the cast iron support of the bronze journal box, at the commutator end of the armature, is turned on its inner end to receive the brush yoke.

The steel armature shaft is 16½ inches long and ½ inch in diameter at the journals, and 11/16 inch in diameter between the journals. The larger part of the shaft

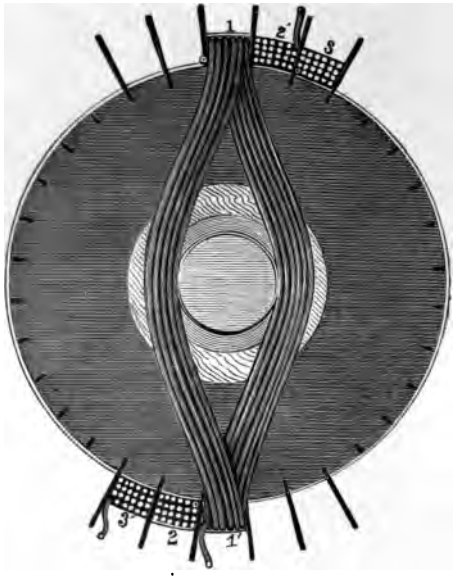


FIG. 303. Arrangement of the Layers at End of Armature Core.

is 9½ inches long. Sufficient end chase is allowed in the armature journals to cause the surfaces to wear smoothly.

On the central portion of the armature shaft is placed a wooden sleeve, 1 1/16 inch in diameter; on this are mounted the thin sheet iron disks forming the armature core. These disks are 2⅜ inches in diameter.

They are arranged in series of five, with tissue paper between the disks, and between the series of five are placed several thicknesses of paper. Enough disks are clamped together on the shaft to make this portion of the core $3\frac{1}{2}$ inches long. The cast iron disks between which the sheet iron disks are placed are $\frac{1}{4}$ inch in thickness and $2\frac{1}{8}$ inches in diameter. One of them is fixed on the shaft, the other being held in place by a hexagonal nut screwed on the shaft. The cast iron disks have their outer corners rounded, and in the

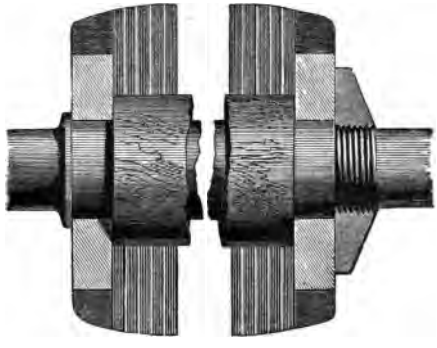


FIG. 304. The Ends of the Armature Core.

edge of each are formed thirty-two equidistant radial slits $\frac{1}{32}$ inch wide. In these slits are inserted slips of vulcanized fiber for separating the different pairs of coils during the operation of winding.

It is impossible to describe the Edison winding without depending mainly on the diagrams, Figs. 301 and 302. There are two series of coils; that is to say, there are two coils in each division of the armature There are thirty-two bars in the commutator, which are numbered consecutively from 1 to 32.

The armature core and shaft are thoroughly insulated by means of paper coated with an adhesive varnish. Jute string ribbon is wound on the face of the core as a further protection.

The wire used on the armature is No. 21 copper wire, double covered; the inner covering being of silk, the outer of cotton.

Leaving an end out for connection with the commutator coil, No. 1 is begun at 1 and wound in four layers, with six convolutions in each layer, the outer terminal coming out at 1′. These ends are marked respectively 1 and 1′ in such a manner as to avoid any possibility of the detachment of the marks. If this caution is observed, much trouble may be avoided. A good way to mark them is to place a tag of parchment, or parchment paper, on each end of the wire, with the number marked on.

After winding coil No. 1 the armature is turned half way over and coil No. 2 is wound and marked in the same way, with 2 on the inner end of the coil and 2′ on the outer end. The coil is then reversed and coil No. 3 is wound and its ends are marked in the same way, and so on until the first series of coils is finished, the last coil of the series being marked 16 and 16′.

The first coil of the outer series is No. 17-17′. This is wound on the top of coil No. 1. The armature is turned over and No. 18 is wound on the top of No. 2, and so on until all of the outer coils are in place.

Before winding, the inner end of each wire is wrapped in jute string ribbon to a point within the end of the armature core, and it is further protected by a wrapping of thin adhesive tape. The outer end of the coil is covered in the same way.

About three pounds of No. 21 wire are required for the armature. The length of wire in the first inner coil is 26 feet 6 inches. The length of wire in the last outer coil is 35 feet.

The commutator cylinder* is formed of 32 bronze bars having beveled ends and radial arms for receiving the wires. These bars are clamped in position on a sleeve having an under-cut flange, by a countersunk washer and a nut screwed on the sleeve. Mica is inserted between the commutator bars, between the bars and the sleeve, and between the ends of the bars



FIG. 305. The Armature with Parts Broken Away.

and the flange and the washer. The radial arms extending from the commutator bars each have a slot in the end for receiving the terminals of the coils.

The coil terminals are arranged in groups of 16, the wires of each group being parallel. The terminals are carried around and attached to commutator bars which are about 90° from the planes of the coils to which they belong, thus making the winding more symmetrical and at the same time permitting of a better arrangement of the brushes.

The coil terminals are inserted in the slots of the arms of the commutator bars and soldered with soft

* For further points on Commutators, see Supplement 600.

solder, the connections being made in accordance with the diagram, Fig. 301.

The wires, where they cross at the back and front end of the armature, are separated by sheets of mica. Where the winding crosses at the rear end of the armature the wires are spread out so that they are only one layer deep.

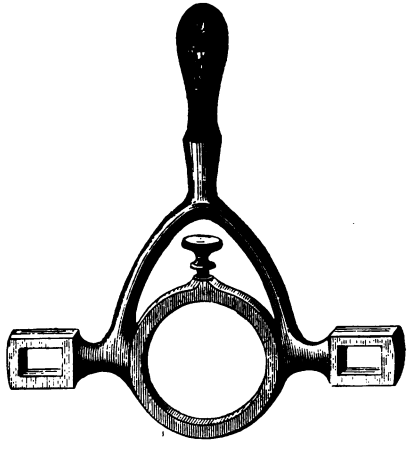


FIG. 306. The Brush Yoke.

When the winding of a coil is finished, the terminal is fastened by stout threads inserted in the coil before winding the last three convolutions, and tied after the coil is complete.

A vulcanized fiber collar, a little larger in diameter than the commutator, is slipped over the commutator bars and placed against the radial arms of the bars as shown. The edge of the collar is grooved and a canvas cover is fastened to the collar by tying it in the groove. It is then drawn over the terminals and

fastened by the first ring of binding wire on the armature. At the opposite end of the armature a similar collar and cover are provided.

Before covering the terminals with the canvas they are wound with twine to give the end of the armature

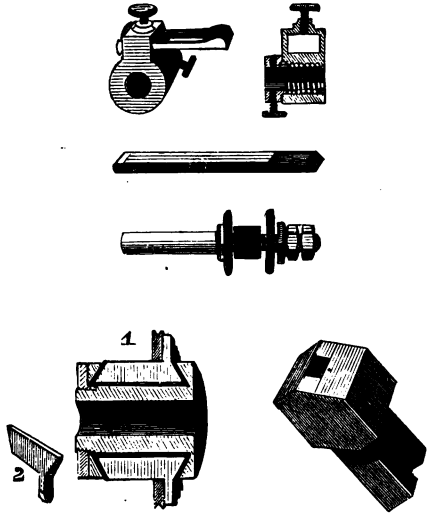


FIG. 307. Details of the Brush Holder, the Commutator Cylinder, and Brush-holding Jig.

a symmetrical shape. The winding is varnished with shellac before its cover is applied, and the cover is varnished after it is secured in place.

The binding rings are formed of brass wire, wound tightly over a layer of mica interposed between the wire and the binding. The binding wire is secured by clips and soft soldering.

The brush yoke is provided with wooden handle by

which it may be moved and a binding screw by which it is clamped in the position of use. In mortises in the ends of the yoke are placed insulating blocks, in which are inserted the brush-holding studs. These studs are each provided with a nut for clamping the brush holder cables which communicate with the leads at the side of the pole pieces.

On each brush-holding stud is placed a sleeve fastened with a set screw, also a loose sleeve connected with the fast sleeve by a spiral spring concealed within it. The loose sleeve is furnished with a brush clamp for holding the brush, which bears on the commutator cylinder with a yielding pressure. The brushes are formed of spring copper wires fastened together at their outer ends with soft solder.

A jig goes with each machine for clamping the brush and guiding the file while renewing the brush ends.

The speed of the motor on a 125 volt circuit is 2,400 revolutions per minute. The speed at which the armature is to be driven in order to generate a current having an E. M. F. of 125 volts is 2,730 revolutions per minute.

According to the new rating the machine here described is a 0.5 kilowatt machine, which, when used as a generator for supplying lights, will generate sufficient current to bring to full candle power nine 16 C. P. 112 volt lamps, and when used for power it is a $\frac{1}{2}$ horse power motor at a rated volt. It is guaranteed to give 0.47 horse power at $\frac{7}{8}$ of its rated volts.

THE UTILIZATION OF 110 VOLT ELECTRIC CIRCUITS FOR SMALL FURNACE WORK*

It occurred to the writer in wiring up a couple of experimental arc lamps across the feeders of an incandescent lighting system, that a laboratory electric furnace could be operated on a series carbon plan, without disturbing the protecting fuses of the circuit. This idea of concentrating a pair of arcs within a small crucible or furnace, using only the amount of resistance wire located in the tops of the lamps, proved to be crude, the current taken being excessive upon introducing a charge for fusion, when its character embodied fair electrical conductivity. In order to obviate this difficulty, as well as to compensate for the lowering of resistance due to eddy currents between the carbons, a triple series arc was formed requiring only a short length of German silver wire to steady its action. With this arrangement the most successful results were attained, and with the furnace, as finally constructed upon this plan, many metallurgical processes were carried on, a 12 ampere fuse placed in each leg of the current supply being sufficient. The little furnace illustrated in Fig. 308 is capable of producing calcium carbide in twenty minutes from the time the current is switched on, the fuses remaining intact throughout the operation, if a short length of resistance wire is introduced into the circuit. With this arrangement it is possible to separate the carbon electrodes $3\frac{1}{2}$ inches without extinguishing the triple arc. It is the intention of the writer to describe in detail the construction of this little plant, and fur-

* By Nevil Monroe Hopkins.

Fig. 308. Partial Section of "Serlow Carbon" Laboratory Electric Furnace.

Fig. 309. Plan View of Furnace, showing Connections.

nish carefully prepared directions for making small quantities of calcium carbide. This compound is chosen because of its exceedingly useful and interesting characteristics, and because of the numerous inquiries the writer has received in regard to its formation on a small scale. Calcium carbide is a highly refractory body, its preparation requiring the highest temperatures, and its successful production by means of this small electrical equipment urges experimentation with other compounds requiring less energy and a lower temperature.

Fig. 309 will enable us to understand the mounting and connecting of the carbons, being a plan view of the system. The steps in putting together this little equipment should consist in forming and lining the furnace proper. The shell is made from sheet iron, cut to exactly incase one of the common sizes of fire clay slabs. The exact size and shape of this furnace is, of course, immaterial, provided the length is not over 13 inches from end to end, as shown in Fig. 311. Should the length exceed 13 inches, standard electric light carbons would not prove long enough to meet at the center. As the fire clay slabs adapted to our purpose vary somewhat in length, definite dimensions are not given, but those shown in Fig. 310 will be found useful as guides, and are approximately suited to the average sized slab sold for backing up fire places and stoves, which are plane on one side and fluted on the other. Having procured four of these slabs, the sheet iron (No. 18 or 20 gauge) may be marked off carefully and bent to form the shell. The overlapping sides are drilled through and securely riveted together. One of the fire clay pieces is now placed in the shell on either

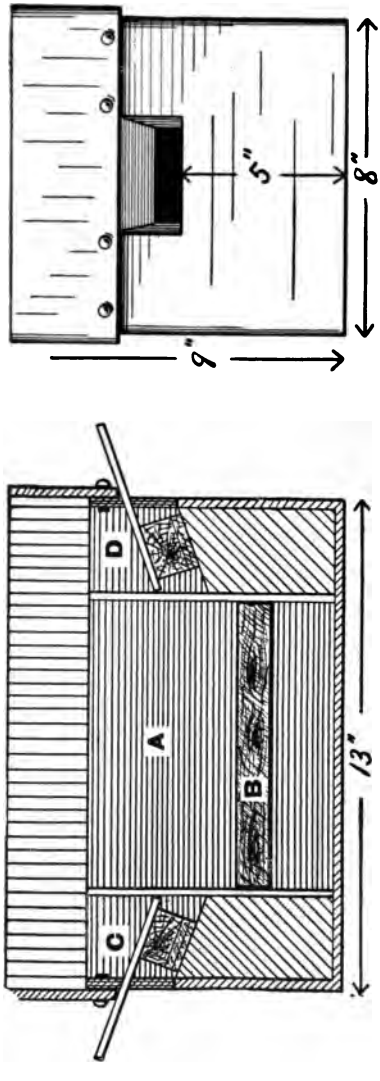


FIG. 310. Method of Forming and Lining Furnace.

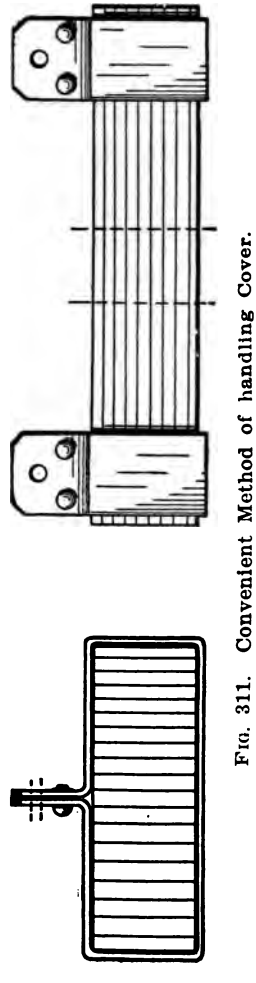


FIG. 311. Convenient Method of handling Cover.

side (the fluted surface next to the iron) and a large fire brick dropped in between them. These large fire bricks come with a recess in the top, as represented in Fig. 308, which is desirable for collecting small fusions. If the three pieces of fire clay fit nicely in the shell, the fire brick is removed temporarily, and our attention given to cutting one of the slabs in half to form the ends of the lining.

In Fig. 310 a section of the shell is shown, where *A* represents one of the side slabs in position, running from end to end, as illustrated by the horizontal shading. These slabs may be had about 12½ inches in length by about 8 inches in width and 2 inches thick, which serve for this lining nicely. The end pieces must be cut off at an angle to form the bottom of the incline leading into the furnace. These are represented in the drawing by section, in oblique lines. The fire clay is cut with a cold chisel and hammer, working slowly with uniform blows, exercising some little patience, until the pieces have the proper shape. The angle must be determined by trial with the shell, which is cut down by means of heavy shears, within 5 inches of the bottom, being about 5½ inches in width. The metal flap, resultant of this cutting down, is sharply bent over and cut off, the edge being smoothed with a large flat file. A band of iron riveted around the top, as illustrated, crowns the opening, and must be adjusted as to height, by the size and thickness of the fire clay lining which has been procured.

To complete the furnace proper, it is only necessary to put in place the angle pieces, and secure in position temporarily four pieces of glass, in order to form the top of the inclined entrance. The wooden brace, *B*,

is cut to the proper length to press the vertical glasses (shown in simple ruling) against the end pieces of fire clay, and small wooden blocks made to support the glass plates on the incline, as illustrated, leaving a 2-inch space. The height of the vertical glass plates must be just equal to the height of the side slab, *A*, and the inclined pieces must come nicely in contact with them. The two spaces formed, *C* and *D*, are now filled in with "stove fix" or other fire clay compound made plastic by the addition of a little water. This compound may be had ready to mix, and is applied with a trowel. The glass plates must be left in position over night, in order that the material which they support may set. They are then withdrawn together with the wooden brace, and the fire brick dropped into the bottom to stay. An additional quantity of the stove compound is made up, and all cracks and crevices plastered in. When this finally sets, a strong and durable furnace is produced. It should be heated up slowly for the first time uncovered, in order to expel all moisture. The top, which consists of the fourth piece of slab, is cut through by means of the cold chisel, and is afterward smoothed with a large rasp.

The method of suspending the cover is illustrated in Fig. 311, the iron bands coming over the fire clay walls, on the inside, being thus protected from the heat of the arcs. Having completed this portion of the work, the base, platforms, and screw feed must be put together. The base, upon which the entire plant rests, consists of a heavy pine board, 4 feet in length by 8 inches in width. The furnace is mounted upon three common bricks (2¼ inches in height) and placed at

the center of the board to facilitate the design and construction of the inclines, which must be very accurately pitched, in order that the carbons may be fed into the furnace without coming in contact with the openings. Should they touch, however, a couple of mica sheets must be applied as a precaution against short circuits. These inclines are made from 1 inch pine boards, 6 inches in width and 16 inches in length. These boards are mounted upon upright pieces of wood of the same weight for trial, but are not screwed on until the screw feed is put in place, which is attached

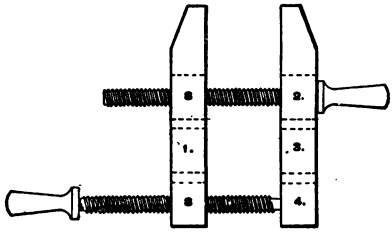


FIG. 312. Sections of Clamp as applied to Screw Feed.

from underneath. Of course the inclines must be carefully adjusted to any specific furnace, but the height of the front and back supports will be about 8 and 3¼ inches respectively. These may be attached at once by means of strong angle irons as illustrated in Fig. 308. To form the screw feed, select a large sized furniture maker's clamp, with wooden screws at least 18 inches long. Fig. 312 illustrates such a clamp, the sections to be sawn through to make the bearings and screw collars being marked in dotted lines. The sections marked *S S* will be found to contain the screw threads, and serve for the center traveling pieces upon which

the blocks and electrodes are mounted. The sections 1, 2, 3, and 4 serve for simple bearings, after being carefully drilled through with a bit and brace, exercising great care in boring, to secure centrally located straight holes. These are screwed on to the board from underneath, and as the wood from which the furniture clamps are made is very hard, gimlet holes must be provided for the reception of the screws to prevent splitting. These gimlet holes must have considerable depth. Upon the traveling pieces are mounted two blocks 6 inches long, 4 inches wide, and about 1½ inches in thickness. Three brass tubes are carefully mounted upon each of these, of the right size to receive electric light carbons (the longest kind, copper coated) with a tight fit. These tubes are secured as shown in Fig. 309 by means of heavy brass straps. The carbons are placel in position, about an inch of the end left protruding to allow brass spring clips to be pushed underneath. With this spring adjustment, the carbons can be quickly withdrawn or easily regulated. The connections, which should consist of double insulated wires (No. 16 gauge), are soldered to these clips in the manner indicated. It will be observed by referring again to Fig. 308 that the carbons may be slowly withdrawn by turning the screw, or they may be pulled out of the furnace by the handle of the screw when it is necessary to remove the furnace from the base.

The furnace is now ready for connecting up and a trial. Adjust all six carbons carefully, making sure that they are all in contact. When the triple arc once forms, they require very little attention, and, as stated, will continue to burn when the distance between their

ends exceeds 3 inches, with a charge of coke and lime as the conducting medium. Fig. 313 shows the scheme of proper connections with a 110-volt electric lighting system. The main conductors, or feeders, are represented at the bottom by heavy horizontal lines and are joined as indicated direct to a porcelain fuse block, *F*. This connection should be made as near the meter as possible, in order to avoid annoyance from intermediate fuses. In addition to this, the capacity of the meter

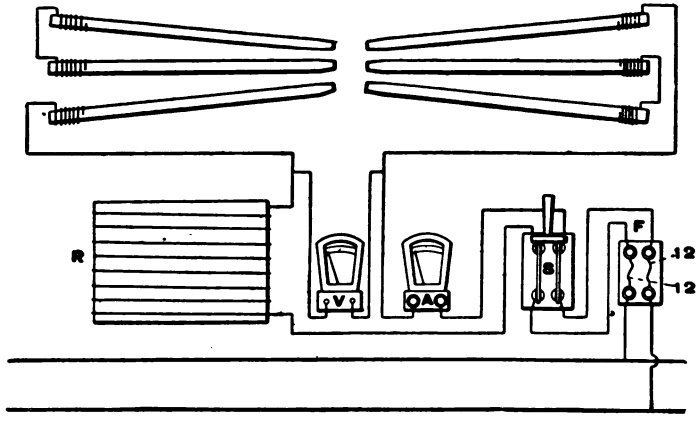


FIG. 313. Diagram of Connections, with Ammeter and Voltmeter arranged for studying the Behavior of Compounds within the Arc.

should be ascertained, which should allow of a 25 ampere load. In other words, a 45-light meter will be large enough, a standard 16 candle power lamp taking about 0.6 ampere. Place a 12-ampere fuse in each side of the fuse block, as shown, and join the same to a small knife switch, *S*. Should the reader possess an ammeter (of fully 50 amperes capacity), it should be included in the circuit, and a voltmeter should be

joined across the connections of the arcs if possible. The resistance, *R*, consists of 20 feet of doubled German silver wire, No. 22 gauge, Brown & Sharpe.*

To make this resistance in convenient shape, the wire should be wound about a large fire clay slab, which serves for sufficient insulation and resists the effect of the heating up. This slab with its wire must not be placed near woodwork. The furnace should be run for fifteen or twenty minutes, for the first time without its cover and without a charge, moving the carbons back and forth and testing their centering, etc. Should the arc go out, the feed is screwed down until contact is again made and the incline rapped with a mallet in order to cause the points of the carbons to vibrate or rub together. In doing this work with the cover off, use strongly smoked glasses to protect the eyes from unnecessary strain. Having mastered the handling of the equipment we are now ready for experimentation, and will proceed direct with the preparation of calcium carbide. To produce a laboratory quantity of this compound, follow closely the directions given. Weigh out 18 ounces of good unslaked lime (calcium oxide, CaO), and reduce to a granulated form in a large iron or porcelain mortar. Place this portion of the charge on a large sheet of manila paper and prepare for the grinding of the coke. Do not attempt to use charcoal, as it is too light and floury, oxidizing away in the air without combining with the lime.

Select either good coke or procure a lot of broken electric light carbons, and weigh out 16 ounces of the

* This wire requires much care in handling, and, if allowed to tangle or kink, breaks very easily. It is very brittle.

fragments. These must now be pounded to small pieces and afterward granulated in the iron mortar to about the same size as the pieces of lime. The coke and lime should now be thoroughly mixed together on the large sheet of paper preparatory to grinding in an iron coffee mill. These mills come all of iron, designed to screw up against the wall, and are equipped with a regulating device for grinding coarse or fine. The money put in a mill of substantial character will be well invested, as it will prove of great value in a laboratory or experimental shop for reducing many substances to powder. The granulated lime and coke are poured into the mill and ground to the finest meal, passing the mixture through several times to insure an intimate mixing as well as a fine powder. Should a mill not be at hand, the charge may be reduced to the proper fineness, although requiring much more labor, by means of the large iron mortar. The pestle of the mortar is ground to the right and the mortar rotated to the left with the palm of the left hand. There is a little knack in doing this, and with a little practice, but with considerable work, the lime and coke may be suitably prepared for fusion.

The powdered charge must be put away in airtight receptacles, if it is not intended for immediate use, as the lime in the finely powdered state quickly slakes if left in contact with the air. Should we use the mixture without thoroughly grinding, which is a very dark slate color, it will be found a very light gray upon shutting down the furnace after a run, showing that most of the carbon has gone off as carbon dioxide and carbon monoxide, leaving the unfused lime behind. We can now start the furnace for actual work and

feed four or five ounces of the charge in the arc as soon as well started, observing the voltmeter and ammeter, if a study of the resistance of furnace fusions is to be made. The carbons are drawn gradually apart, and additional quantities of the charge added from time to time. The cover is kept on as much as possible, only removing it to add more material and to heap

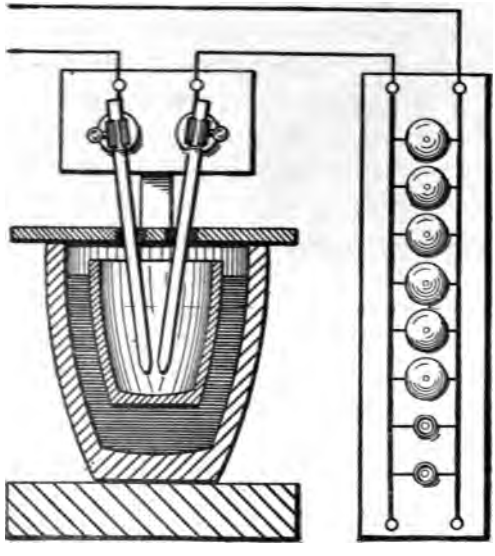


FIG. 314. Furnace for making Solders and other Alloys having Low Melting Points.

the compound about the triple arc by means of a spatula. After a twenty minutes' run, during which time the compound is frequently heaped about the points of the electrodes, the switch may be opened and the furnace allowed to cool. Should one of the fuses blow out during the run, it should be immediately replaced by one of the same capacity and a small

amount of additional German silver wire added to the circuit, although the 20 feet of the double material will probably afford all the protection necessary and steady the arcs in a very satisfactory manner.

A variable rheostat of low resistance included in the circuit would be a great convenience, allowing the current flow to be adjusted to the capacity of the fuse wires to a nicety. A few runs with the furnace will enable one to become quite expert in forming calcium carbide, working with a 3-inch arc without allowing it to go out. When the furnace has cooled, a number of large masses of the carbide will be found in the bottom of the fire brick hearth, which may be thrown immediately upon water to obtain acetylene gas or stored away in airtight cans or jars for future use. If left open in the air, it is slowly attacked by moisture and is decomposed. Before suggesting other work for small preparations, the introduction of a very small crucible furnace may be of interest. Fig. 314 illustrates the simplest form of crucible equipment designed for operation on the 110-volt circuit, with six or eight 32 candle power lamps arranged in a bridge in multiple as indicated. A large sand crucible or ordinary flower pot is filled with granulated fire clay or other poor conductor of heat, and a smaller crucible placed inside. The whole is stood on a fire brick and the large pot or crucible is provided with a clay cover having holes for the reception of two carbon electrodes. The stands sold for supports in chemical laboratories make the most convenient holders for the carbon rods.

The furnace depicted in Fig. 315 is capable of doing more work, in fact, as much as may be wished for on a small scale, if the experimenter is so situated that he

may have as much current as he wants. The small crucible is drilled through the bottom, and one of the electric light carbons cemented in place, or simply held in position by a tight fit. The outer incasement in

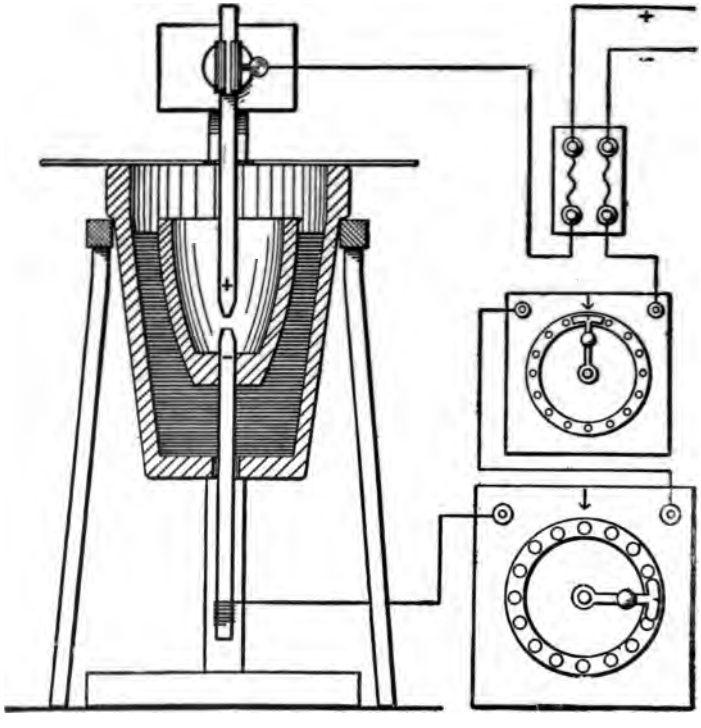


Fig. 315. Furnace for melting Brass, Copper, etc., for Harder Alloys, and reducing Small Quantities of Metallic Oxides to their Respective Metals.

this design consists of a large flower pot, supported on a small iron ring stand, also to be had from chemical dealers. This is covered by a heavy plate of mica with a central hole for the carbon. By putting in series two or three rheostats the current may be easily

controlled, and if heavy fuses are installed, and if there is no fear of injuring any meter, a very fierce and intense arc may be maintained. Use only the coppered carbons, and solder their connections to them. The writer suggests experimentation with alloys, in connection with these small crucibles (sand crucibles, plumbago, or graphite), using borax in some cases and charcoal in others (here the light floury charcoal is to be preferred), in order to fuse the bodies in a neutral atmosphere.

By using an excess of charcoal constantly in the crucible, the inert carbonic acid gas which is formed will expel the oxygen from the crucible and prevent oxidation of the metals experimented with. Nearly all the metallic oxides may be reduced in the presence of carbon with a sufficiently high temperature, providing an interesting field for work. Small masses of aluminum and aluminum bronze may be formed in the crucible furnace illustrated in Fig. 315, or in the large triple arc equipment, although only on a very small scale. Aluminum oxide (Al_2O_3) may be directly reduced in the arc in the presence of carbon by introducing an intimate mixture of the oxide and powdered graphite. The aluminum oxide may be bought, or may be prepared on a very small scale from clay or alum as follows: Digest 8 ounces of clay in a mixture of hydrochloric and sulphuric acids in a glass flask (HCl 3 parts, H_2SO_4 1 part) for about an hour. The fluid is mixed with four or five ounces of water and filtered. An excess of ammonia (ammonium hydroxide) is added, and the white precipitate collected on a large filter and allowed to dry. It is then mixed with the graphite and the two ground together. From alum, it

is only necessary to add the ammonia to a strong solution of alum in water, and treat the resultant precipitate in a like manner. Of course this process is only a little chemical exercise, and is only given for the benefit of those who wish to attempt the entire process, although of no commercial value, the manufacture of aluminum embodying entirely unlike methods.

For the benefit of those who have never experimented with the electric arc, the writer includes in the suggestions offered a pair of strongly smoked glasses, to be worn whenever the arc is exposed. To work without glasses is to expose the eyes to severe strain and possible injury.

RECORDING TELEGRAPH FOR AMATEURS

If the question of utility controls one in making and trying a piece of apparatus, it is useless to expect to realize anything in the way of profit from the recording telegraph illustrated and described; but a few interested amateurs can co-operate, and with a wire and transmitter for each can secure a practical knowledge of the workings of some of the large telegraph systems and of some of the applications of electricity, which could not be secured in any other way. The expense would be slight, when there is a joining of amateurs for one purpose.

It is assumed that an ordinary sounder is available for the central office recorder, and that every subscriber will furnish a transmitter, a wire to communicate with the central office recorder, and battery sufficient to operate one branch of the central office system.

In making the central office recorder, a common sounder is pressed into service. It is provided with a

stylus-holder which is clamped to the free end of the armature lever. The stylus is a piece of steel wire 1-16 inch in diameter and 1 inch long, with a rounded and hardened point. It is clamped in place by a set screw.

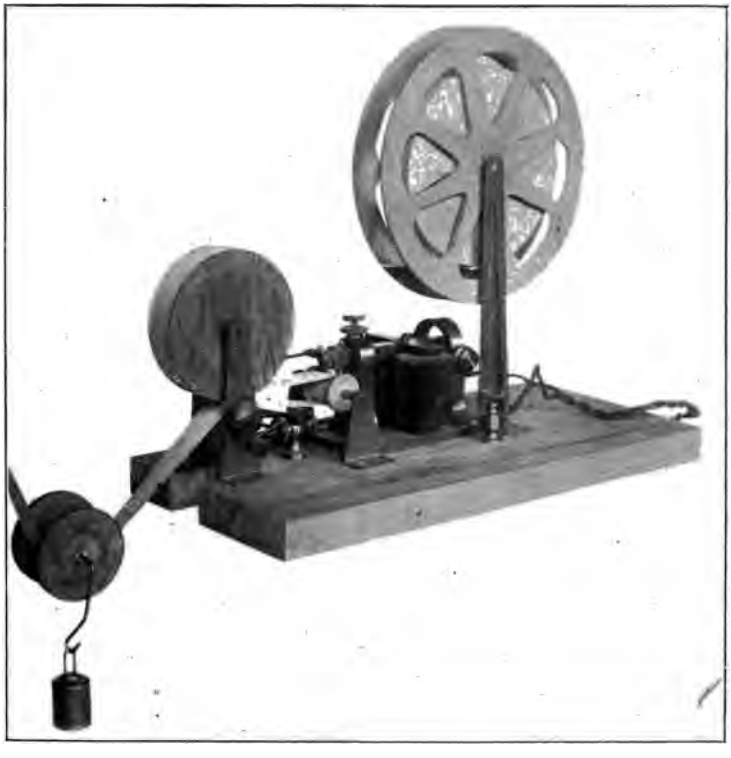


FIG. 316.
The Receiving Instrument of the Recording Telegraph.

Under the free end of the armature lever is journaled an arbor, carrying a wooden roller having a V-shaped peripheral groove at the center, exactly under the

stylus; so that when a paper strip passes over the roller, the stylus can make a slight depression in the paper, when the sounder magnet is actuated.

The principal features of this telegraph are a simple transmitter for giving fixed calls, like a call box, and the mechanism for carrying the paper tape over the grooved spool and under the stylus. The roll of tape as purchased from the dealer is carried on a wooden reel, supported by a standard at the rear of the sounder. Between two standards in front of the sounder are journaled two rollers, *a b*. The roller *a* is flanged and provided on its periphery with three or four rubber bands, to give it frictional contact with the paper tape. The lower roller *b* is covered with a piece of rubber tube and the shaft of this roller carries a small governor *c*, for regulating the speed of the tape. The tape extends over the roller *b*, thence downward under the flanged roller *d*, then upward to a fastener. The roller *d* is provided with a weight which actuates the mechanism.

It will thus be seen that the paper tape is carried through the machine by the action of the weighted roller *d*, and its motion is regulated by the governor *c*. The governor *c* consists of a slotted hub *f*, links *g g*, pivoted in the slots of the hub, a slotted sliding block *h*, placed loosely on the shaft of the roller *b*, weighted arms *i i* pivoted in slots in the block *h*, and pivotally connected to the outer ends of the links *g g*, and a light spring, *j*, tending to draw the weighted arms *i i* toward each other. The block *h* is provided with a leather washer *l*, which produces necessary frictional contact with the standard, when the weighted arms are thrown out by centrifugal action. The tape reel is provided

with a slight spring for checking its motion when the paper feed stops. In the side of the block which carries the stylus is inserted a small stud, in which is clamped a wire *m*, having its free end near the side of

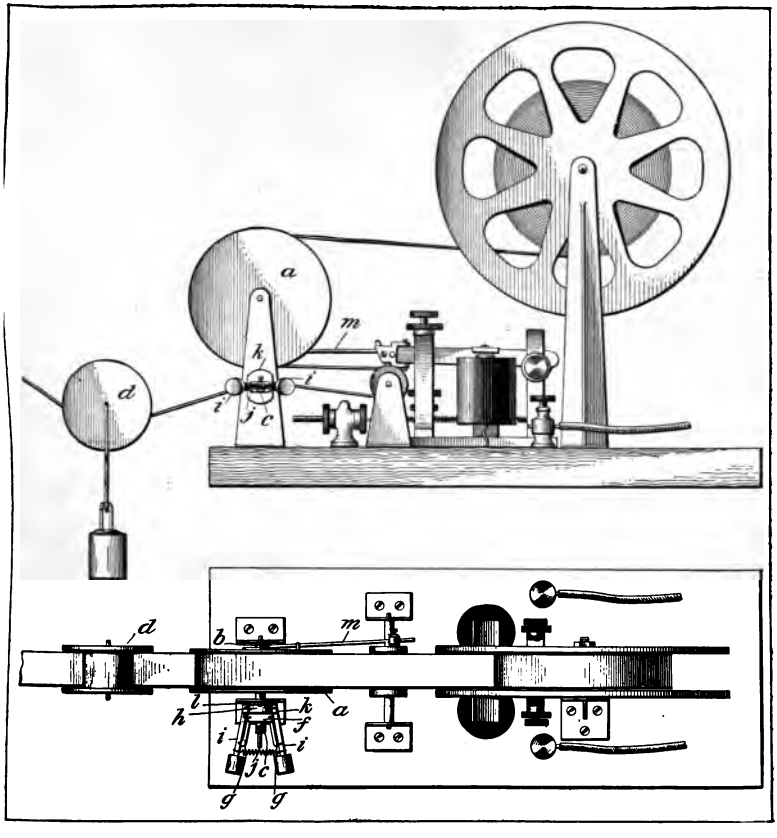


FIG. 317. Diagram of the Receiver.

the roller *a*, flattened and turned up at right angles. The flattened end of this wire *m* lies in the path of a small pin projecting from the roller *a*, so that when-

ever the armature lever is drawn down by the magnet, the pin is released, and the roller *a* is allowed to turn, but when no current passes the magnet, the armature lever rises and brings the flattened end of the wire *m* into the path of the small pin, and stops the movement of the roller *a*, and consequently arrests the progress of the paper, until the pin is released by another action of the armature lever. Binding posts placed at the rear of the sounder are connected with the magnet electrically in the usual way. To transmit a signal over a line connected with this instrument, it is not necessary to understand the telegraph alphabet, nor to know anything in regard to telegraphy. The signals are pre-arranged, so that the operation of sending is purely mechanical.

The signal board shown in detail in Fig. 318 was invented and patented years ago by William Hadden, but the patent has long expired. This simple device consists of a board, a few inches wide, and perhaps twice the length, depending on the number and length of the messages sent. The board here shown is 4½ inches wide, 7 inches long, and ¾ inch thick, with as many longitudinal grooves formed in it, as there are signals to be given. The signal board must be of very hard wood, and the dots and dashes of the signals are formed by sewing No. 30 plain copper wire through holes extending through the board, from the grooves in front to the grooves in the rear. As the signal transmitter is at present constructed, the copper wire sewed through the first set of holes represents the letters of the Morse alphabet from *A* to *F*, with a dash between each letter. The sewing in the second groove represents the letters from *G* to *J*. The sewing in the third

groove represents the letters from *K* to *M*, and so on. All of the wires forming these letters are connected together at the top of the board, by a wire on the back, which is in electrical connection with the binding post seen to the right in our view of the signal apparatus. The binding post at the opposite edge of the board is

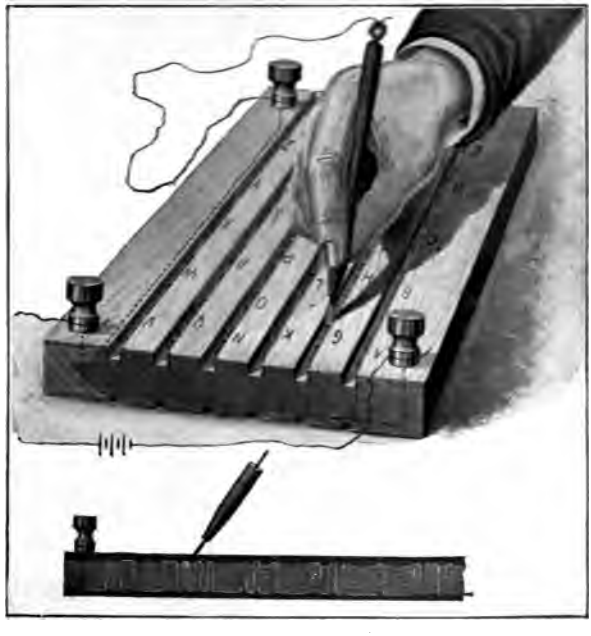


FIG. 318. View of the Transmitting Apparatus.

connected on the back of the board with a third binding post, at the lower end of the board. The third binding post is connected by a flexible cord with a wire, having a flattened end, and provided with a wooden handle. Sending a signal consists simply in drawing the flattened end of the wire with a uniform

speed down one of the grooves. The first two binding posts, being connected with the binding posts of the recording instrument and with a battery, when a signal is sent, the recorder is released automatically, and the detent is constantly withdrawn from the pin in the roller, so long as the signal is being sent, and the mes-

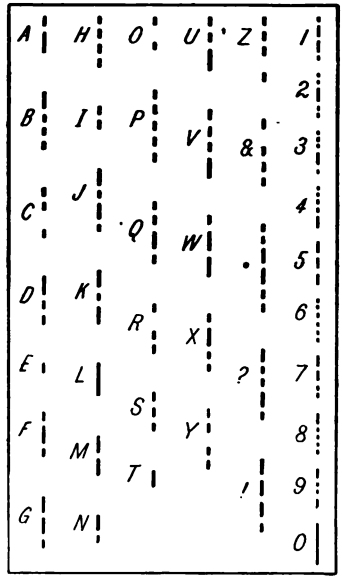


FIG. 319. How the Board is Wired for the Morse Alphabet.

sage is thus recorded. When the signaling stops, the recorder is stopped by the action of the detent.

Several transmitters may be connected with the recorder, and one wire in each case may be dispensed with, by grounding the other at each end.

The recorder will run long enough to record a long signal or several short ones with one raising of the weight carried by the paper tape.

HOW TO MAKE TELEPHONES AND TELEPHONE CALLS

On January 30, 1894, the Bell telephone patent expired and the invention became the property of the public; so that whoever desires to do so can make, buy or sell telephones without fear of infringing the

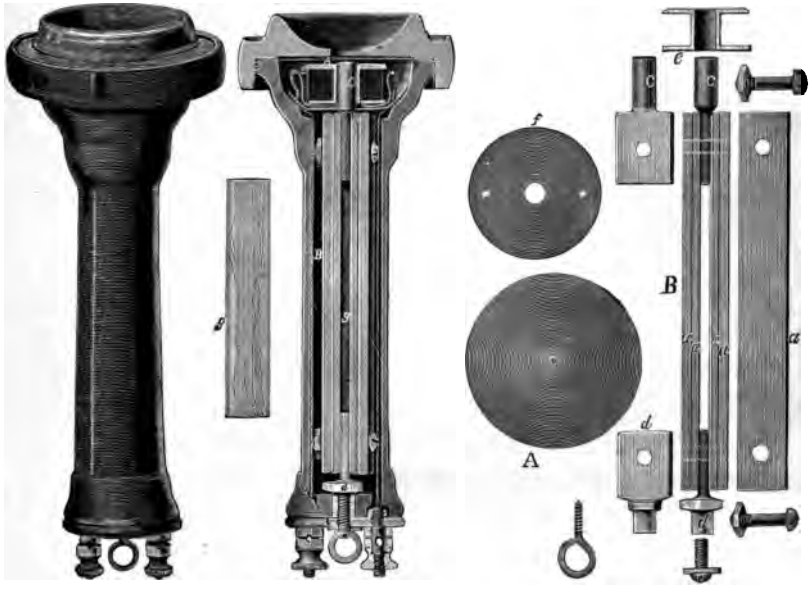


FIG. 320. Details of Construction of the Bell Telephone.

rights of any one. This applies only to the hand instrument now used as a receiver. Patents for other telephone apparatus still remain in force; but enough is available for actual service. With two hand instruments and a suitable call, telephonic communication may be maintained, under favorable conditions, over

a line eight or ten miles long, no battery being required.

To avoid the effects of induction and to secure the best results, a metallic circuit is required. It has been said, on good authority, that with hand telephones used as transmitter and receiver, conversation has been carried on between New York and Chicago, using a metallic circuit formed of heavy copper wire and having very low resistance. The words, it is said, were as distinct as where a transmitter is used, but the volume of sound was somewhat less.

For the benefit of those who are desirous of making telephones for their own use, or for sale, we present perspective and sectional views of the latest and most improved form of telephone, all of the parts of which are shown in reduced size.

The handle is made of hard rubber and the cap, which is also the mouthpiece, is of hard rubber. The diaphragm, A, is clamped at the edge between the cap or mouthpiece and the body of the handle. Very thin ferrotype plate has generally been used for the diaphragm, but thin taggers iron, when protected by a coat of shellac or other suitable varnish, is said to answer better.

The compound magnet, B, used in the telephone, is composed of four thin, flat bar magnets, *a*, arranged in pairs on opposite sides of the flat end of the soft iron pole piece, *c*, at one end, and the soft iron distance piece, *d*, at the opposite end, the magnets being clamped to these pieces, with like poles all in one direction. The space in the center of the magnet between the pole piece and distance piece is filled with a strip, *f*, of wood.

The cylindrical end of the distance piece which extends beyond the magnet is bored and tapped to receive the screw by which the magnet is held in place in the handle. The cylindrical projecting end of the pole piece extends to within 1-100 or 2-100 of an inch of the diaphragm. In other words, it is placed as near the diaphragm as possible without being touched by the diaphragm when the latter vibrates.

On the pole piece, *c*, is placed a wooden spool, *e*, on which is wound No. 34 (Am. W. G.) silk-covered copper wire. The wire fills the spool, and its ends are allowed to project one or two inches. The wire may be wound on the spool in either direction, and it is immaterial which pole of the compound magnet adjoins the diaphragm.

The resistance of the winding varies from 70 ohms as a minimum to 200 as a maximum. When the instrument is to be used both as transmitter and receiver, and especially when it is on long lines, the resistance should be 100 ohms or more. No. 36 wire is used for the winding where the resistance is great. Of No. 34 wire, 263 feet will be required for 70 ohms resistance. For 100 ohms, 373 feet are required. For 150 ohms, 343 feet of No. 36 are required.

In the end of the handle are inserted two binding posts, to which are attached insulated wires (No. 18), which extend toward the diaphragm, their free ends being soldered to the terminals of the fine wire on the spool, so that when the telephone is connected up in circuit with other telephones the current will pass from one of the binding posts through one of the coarse wires, through the fine wire coil, through the other coarse wire to the other binding post.

The Bell telephone has a disk of flexible rubber slipped over the pole piece and over the ends of the coarse wires as a guard against short circuiting. A screw eye is inserted in the end of the telephone handle for suspending the instrument when not in use.

This telephone, when used in the manner suggested, requires neither battery nor induction coil. It is therefore easily connected up for use by electrically connecting the binding posts of one instrument with the binding posts of another. When a number of telephones are connected in the same line, the matter

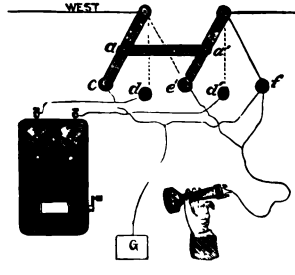


FIG. 321.

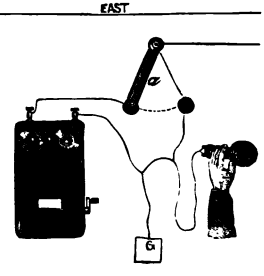


FIG. 322.

Single Wire Circuit.

is not quite so simple. There are many ways of arranging the circuit; we give diagrams of two, one for one line wire with ground connections, the other for a metallic circuit, with a separate circuit for calling.

In the single wire circuit each instrument on the line is provided with a double switch cut into the line as shown in Fig. 321, the pivots of the switch arm *a a'*, being connected with the line wire. The switch arms are pivotally connected with a bar of insulating material, so that they will move together. The arms, *a a'*, may be brought into contact with the points, *d*, *d'*, *e*.

c', and f. A magneto call box is connected with the points, d d', and the arms, a a', are left normally on these points, as shown in dotted lines, so that when any magneto in the line is operated the others will ring. All on the circuit have a special call.

The one called will know whether the signal comes from the east, west, north or south. Suppose it to come from the east, the switch is placed in the position shown in full lines. This cuts out the magnetos, grounds the western section of the line through the point, c, and connects the eastern section with one

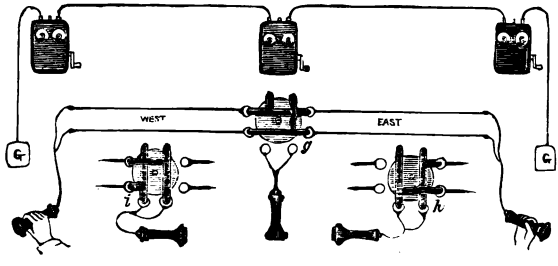


FIG. 323. Metallic Circuit.

end of the telephone cord through the point, c', the other telephone connection being grounded through the points, f e, and ground wire. If the call is from the west, the switch arms, a a', are brought into contact with the points, c' f. The arms, a a', are always left on the points, d, d'. Outside the terminal stations the line is connected with the ground or arranged as shown in Fig. 322, with the line grounded through the magneto or telephone.

In the metallic circuit shown in Fig. 323, the terminal telephones are connected with the ends of the line

wires. Intermediate telephones are cut into the line by means of a double switch, as shown in the cut, in which *g* shows the intermediate telephone cut out, *h* shows it connected with the east and *i* with the west.

A third wire grounded at the ends, and including a magneto for each telephone, runs parallel with the metallic circuit. In this case all of the bells ring at once, and individual signals must be agreed upon.

It is obvious that the information here given in regard to the construction of the telephone may be departed from in minor points, such as the construction of the handle and mouthpiece, but everything relating to the magnet, the coil, and the relation of the magnet and diaphragm, should be strictly followed.

No telephone line is complete without a signal of some kind which will serve to attract the attention of a person in the vicinity of the instrument. A battery call answers very well for short distances, but for a distance of from one to twelve miles or more, the battery has been found impracticable and the magneto call is generally employed. This instrument not only serves a good purpose in connection with the telephone, but it answers very well indeed for general signaling purposes. It is always ready for action, and does not involve the care of a battery.

The line drawings presented herewith are one-third the actual size (linear measurement) of the instrument, and the perspective view is also one-third of the actual size; the only dimension not obtainable from the drawings is the depth of the signal box, which is 3 inches. As all of the dimensions may be obtained from the engravings, it will be unnecessary to repeat them in the descriptive matter.

The pole pieces, A A′, between which armature, B, revolves, are formed of soft gray cast iron, with ears, *a a*, at the top and the ears, *b*, at the bottom, separated by bars, C C′, of non-magnetic material, such as vulcanized fiber, hard rubber, or they may be made from hard wood, well varnished or saturated with paraffine to prevent them from shrinking or swelling. The pole pieces, A A′, are clamped to the bars, C C′, before they are bored out. They are bored out to loosely fit the

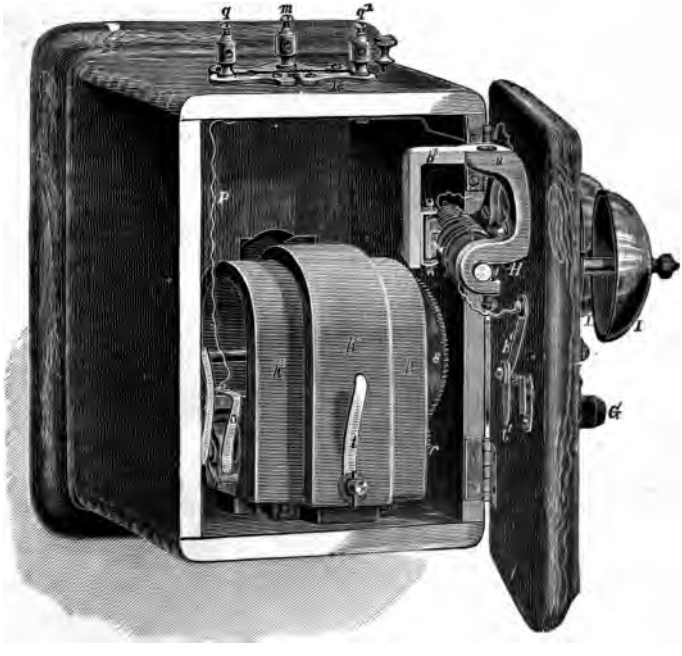


FIG. 324. Magneto-Telephone Call.

armature, B′. The pole pieces are provided with flanges, *c*, which rest upon the bottom of the casing and are drilled to receive screws, *d*, by means of which the mag-

net is secured in place in the casing. In the pole pieces, A A', above the ears, *b*, are drilled and tapped holes, *c*, for receiving the studs, *f*, by which the horseshoe magnets are secured to the pole pieces. The studs, *f*, are drilled for receiving keys, *g*, by which the magnets are clamped in place.

The compound magnet, 2, is composed of three flat steel bars forming U-shaped magnets, *h*, *h'*, h^2, with the space between the poles adapted to receive the pole pieces, A A'. The magnet h^2, fits over the adjoining edges of the magnets, *h h'*, and the three magnets are drilled to receive the studs, *f*, which extend through the magnets and into the pole pieces, the parts being clamped together by keys driven through the holes in the studs, as shown in the perspective view.

The armature, B, is the well known H type of Siemens, made of soft gray cast iron, the shaft, *i*, being cast integrally with the body of the armature. The part, j, which receives the wire is narrower and shorter than the polar extremities of the armature. The armature is turned so that its convex sides will revolve very near but not in contact with the pole pieces. The shaft at the ends of the armature is turned, and to one end is fitted a sleeve, *k*, of insulating material (vulcanized fiber or hard rubber), on which is placed a brass ring, *l*. In the inner side of the metallic ring, *l*, is inserted a stud, *n*, to which is soldered one terminal of the armature coil, the other terminal of which is soldered to a screw, *n*, inserted in the shaft, *i*. The armature is wound in the same manner as an electromagnet, the wire being carried around one arm of the armature until one-half of the wire is in place. It is then carried across the central portion of the arma-

ture and wound upon the other arm of the armature. The wire used is No. 34 silk-covered wire, there being about 1½ ounces of wire upon the armature, or enough to give it a resistance of 200 ohms.

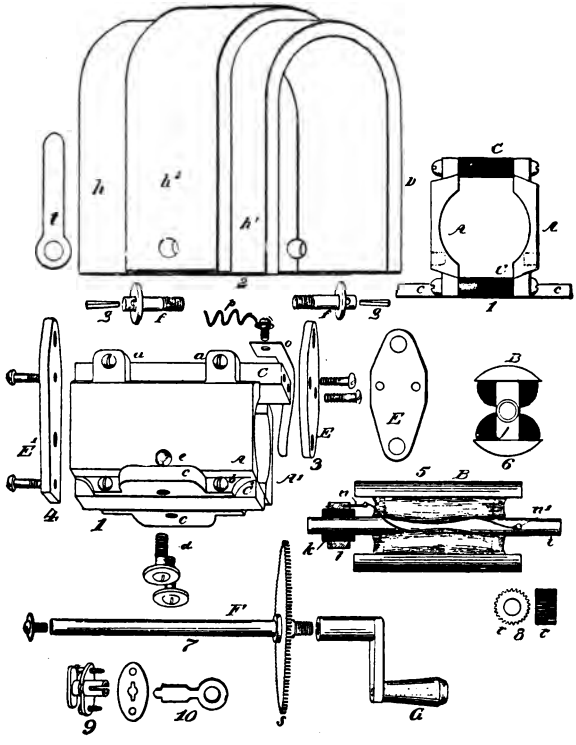


FIG. 325. Details of Magneto-Call—the Generator.

To the bar, C, is secured a brass plate, E, by means of screws which pass through the plate and into the bar. In the plate, E, opposite the center of the bore of the pole pieces, there is a bearing for one end of the shaft of the armature, and in the opposite or upper end

of the brass plate, E, there is a bearing for the driving shaft, F. To the opposite end of the bar, C, and to the bar, C', is secured a plate, E', which is also provided with bearings for the armature shaft and for the driving shaft. To the bar, C, is secured a curved spring, *c*, which bears upon the insulated ring, *l*, and this spring is connected by a wire, *p*, with a binding post, *q*, at the top of the casing.

Upon the end of the armature shaft, *i*, outside the plate, E', is placed a pinion, *r*, and upon the shaft, F, is placed a spur wheel, *s*, which engages the pinion, *r*. The shaft, F, is held in place in the machine by a screw inserted in the end of the shaft, and a washer held by the screw against the end of the shaft and bearing against the plate, E. The crank, C, by which the shaft, F, is turned, is screwed on to the end of the shaft through an aperture in the side of the casing. On the stud, *f*, projecting through the front of the magnet is placed a contact spring, *t*, which is clamped by the key which holds the magnet in place.

The mechanism thus described comprises the magneto generator which generates the alternating current required for operating the magneto bell. The machine is held in place in the casing by the screws, *d*, as already described, and the back of the casing is cut away to let the magnet, h^2, into the back, thus economizing room. To the cover of the casing is attached the magneto bell, H, the magnet and armature of which are placed within the door, while the bells are placed on the outside of the door, the hammer extending through the door and between the bells.

The body of the magneto call consists of a curved casting, *u*, which is secured to the inner face of the

door and provided with loops, *v v'*, for receiving the soft iron pole pieces, *w w'*, of the bell magnet. These pole pieces are held in place in the loops, *v v'*, by screws passing through the side of the loop and bearing against the pole piece. The convex side of the casting, *u*, is provided with a rectangular notch, *a'*, for receiving the L-shaped permanent magnet, *b'*, which is held in its place by a screw passing through the

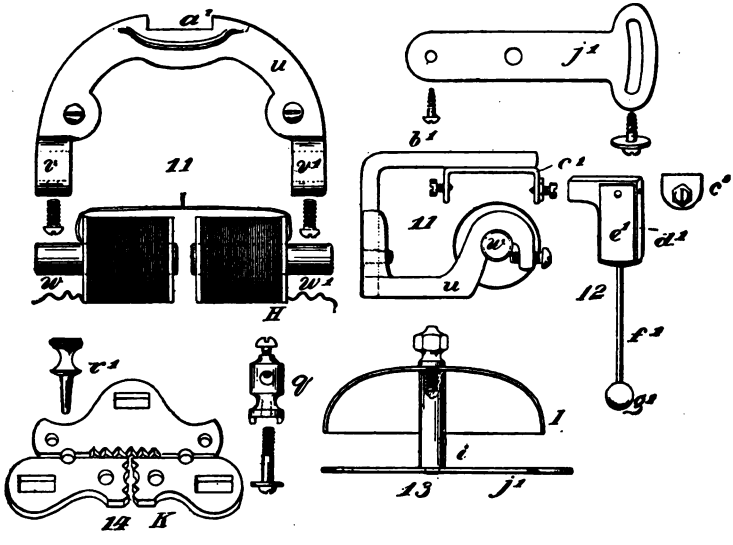


FIG. 326. Details of Magneto-Call—the Bell.

magnet into the casting. To the L-shaped magnet, *b'*, is secured a plate, *c*, which is bent twice at right angles, and in the bent ends of which are inserted pivot screws supporting the armature, *d*, which extends downward between the adjacent ends of the pole pieces, *w w'*. The armature is covered by a strip, *e'*, of copper, and in the end of the armature is inserted a wir

f, carrying at its extremity a bell hammer, *g'*. To the outer surface of the door, and on opposite sides of the bell hammer, are supported two bells, I, by studs, *i'*, projecting from adjustable plates, *j'*, pivoted to the door at one end and provided with a curved slot at the opposite end for receiving a clamping screw, which passes through the slot and into the door. By means of this device the bells may be adjusted so that each will receive a stroke of the same power from the bell hammer, *g'*.

The spools on the pole pieces, *w w'*, contain about 1½ ounces of No. 34 silk-covered copper wire. They are wound in the same direction, and the inside ends are connected together. The outer end of one spool is connected with the upper hinge of the casing, which, in turn, is connected with the binding post, *q'*; the outer end of the remaining spool is connected with a strip, *k'*, of copper attached to the door and connected with a plate, *l'*, which comes into contact with the spring, *t*, when the door of the casing is closed.

On the top of the casing there is a plug switch, which also answers as a lightning arrester. The rear plate of the switch is provided with the binding post, *m*, which is connected with the ground. The binding posts, *q q'*, receive the ends of the line wire, the connections being made as shown in the section on the telephone, pages 358-360.

When the call is placed at the end of the line the call box is grounded by inserting the plug, *r*, between the rear or ground plate and the front plate that is not connected with a line wire. When it is desired to cut the call box out of the line, the plug is inserted in the circular space between the two front plates, the

current passing from one end of the line through one of the binding post to the other portion of the line. When the armature, B, is turned by revolving the crank, G, opposite ends are alternately presented to opposite poles, the consequence being that the rapid changes of magnetism in the armature induce alternate pulsations in the winding of the armature which operate the polarized bell of the instrument, also the polarized bell of the distant instrument, both being normally in the circuit.

While talking over the line it is important to cut out the magnet on account of its resistance, and while signaling over long distances the signals are more effective if the telephones are cut out of the line.

These machines can be purchased for $4, and we therefore doubt if it is profitable to undertake to make them; however, they may be made without fear of legal complications, as they are not patented.

THE END.

INDEX

B

PAGE

Barometer 201
Bas-Reliefs 69
Battery, Primary 227
Brass, Burnished 78

C

Cabinet, Electrical 246
Cabinet, Wall 40
Caloric Engine 176
Carving, Wood 26
Centering 106
Chasing 126
Chime, Electric 237
Chucking 112
Cutters, Rotary 136

D

Drills and Drilling 99
Dynamo, Edison 319

E

Electricity 227-367
Electric Lighting 232
Engines and Boilers, Model, 169-184
Engines, Running 175

F

PAGE

Fluted Work, Turning 10
Frames 36
Furnace, Electric 333

G

Gear Cutting 152
Glass, Stained 51
Grilles and Gratings 31
Grinding and Polishing .. 92

H

Household Ornaments 31
Hygroscope 198

I

Index Plates 147
Iron Work 73

K

Knives, Moulding 9
Knurling 126

L

Lamp, Electric Night 243
Launch Motor, Electric... 298
Lathe, Foot 96
Lathe, Inexpensive 1-7
Lathe, Woodworking on a. 8

M

PAGE

Majolica, Imitation 49
Metal Turning 119
Metal Working 89-168
Meteorology 187-205
Microscope, The 218
Model Making 155
Motor, Edison 319
Motor, Sewing Machine .. 278
Motor, Simple Electric ... 259
Motor, Small Electric 270
Moulding Knives 9
Moulding, Wood 11

O

Ornament, Feather 39
Ornaments, Household ... 31

P

Plaster Objects 85
Portière 57
Pseudo-Ceramics 41

R

Rain Gauge 193
Repoussé 61

S

Sawing, A Wrinkle in 25
Sawing Metals 89
Saw, Scroll 12
Saw Tooth 21
Saw, Wood 8

PAGE

Scroll Saw 12
Silver Work 94
Slide Rest 143
Soldering 90
Spinning Metals 160
Stained Glass 51
Steadying 106
Steam Engine 169

T

Telegraph, Recording 348
Telephone, How to Make.. 355
Telescope, How to Make... 207
Telescopes and Microscopes 207-225
Thermometers 194
Tooth, Saw 21
Turning, Wood 6

V

Vases 41

W

Wall Ornaments 35
Water Motor 181
Weather Vane 189
Whittling 16
Wind Pressure Gauge 190
Wire, Things in 75
Wood Carving 26
Wood Turning 6
Wood-Working 1-29
Work Bench 14

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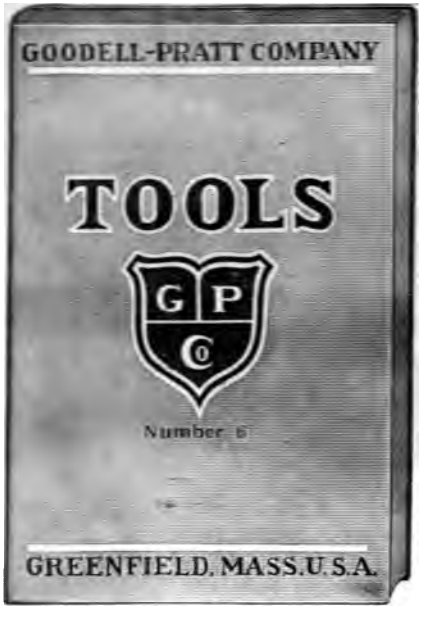
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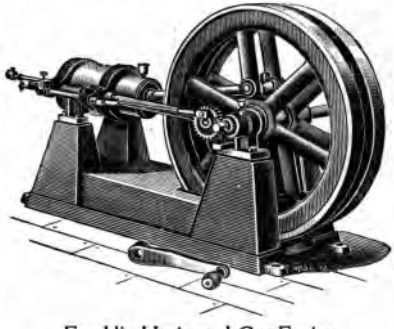


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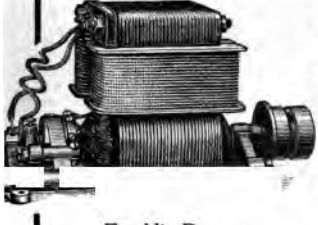
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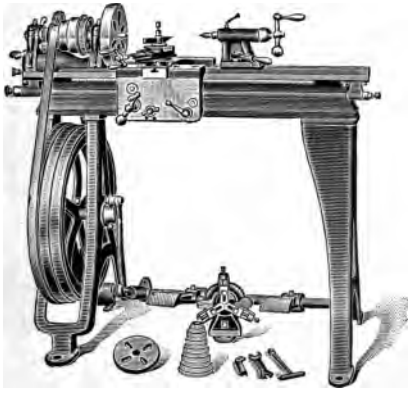
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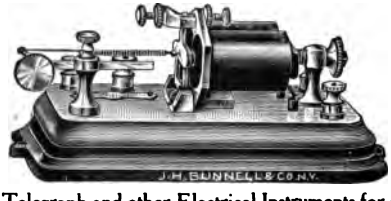
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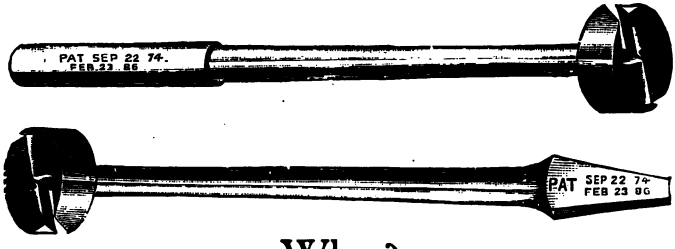
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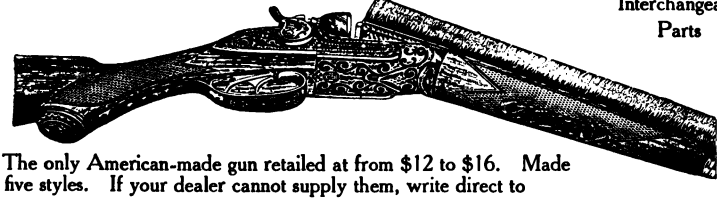
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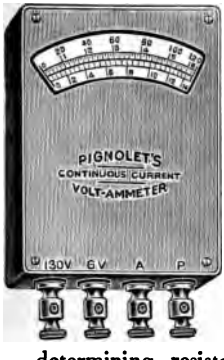
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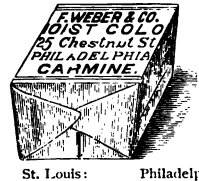
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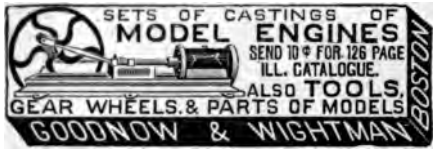
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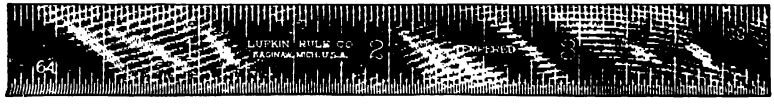
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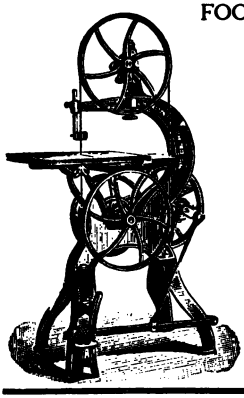
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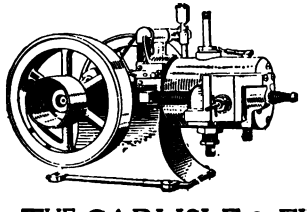
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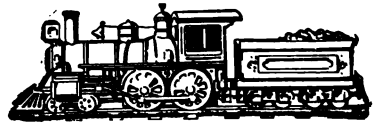
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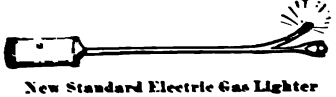
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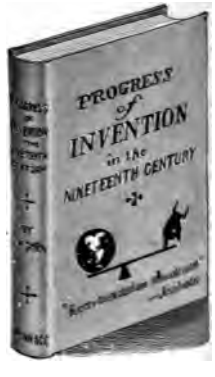
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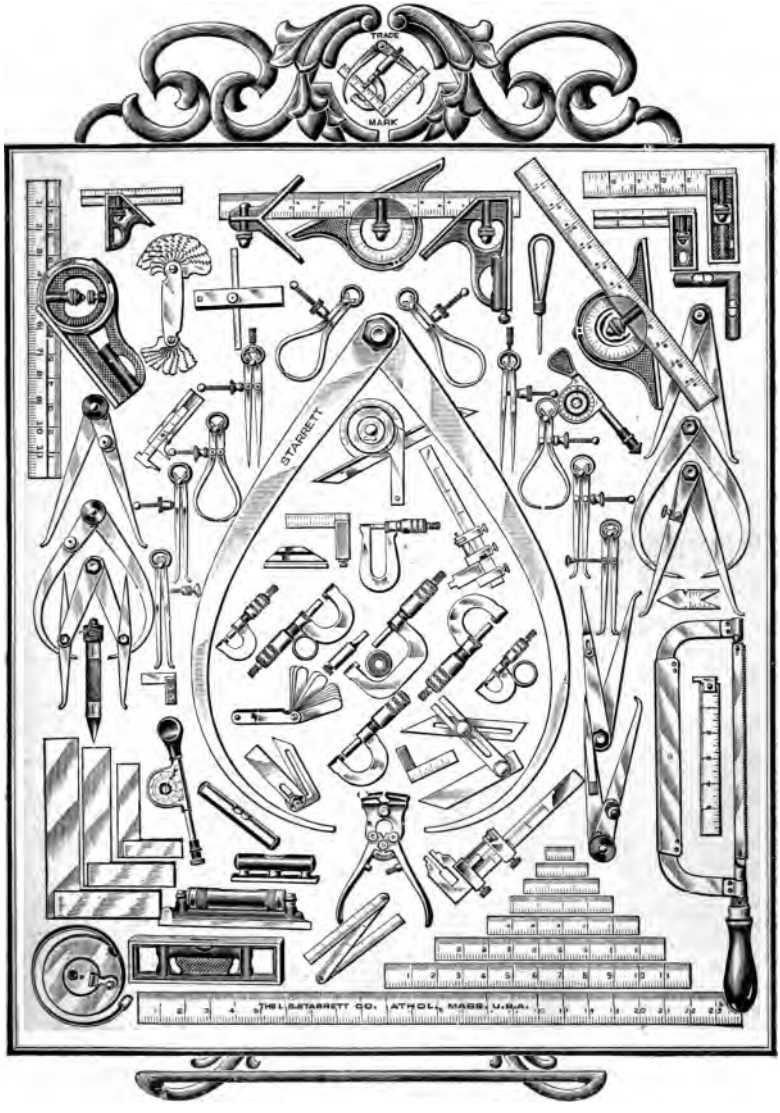
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